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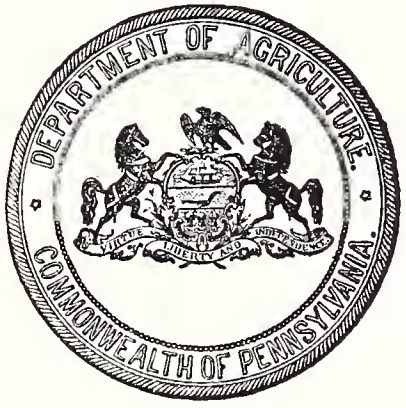
THE IMPROVEMENT OF CORN

IN PENNSYLVANIA,

BY

MR. DE WITT C. WING.



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PREFACE.

Harrisburg, December 31, 1904.

The following Bulletin, No. 133, deals with a subject of more than usual interest to the Pennsylvania farmer. Although Pennsylvania does not rank as one of the first states of the Union in corn production, the value of this important crop exceeds that of any other cereal grown in the State.

One of the first essentials in securing the best results in the production of any cereal crop, is good seed. In recent years experiments have proven that cereals can be improved by systematic selection and breeding, as successfully as it is possible to improve the various classes of domestic animals by the same process.

It is with the hope of increasing general interest in this subject, which may result in the production of better varieties and better crops of corn in Pennsylvania, that this bulletin is issued.

N. B. CRITCHFIELD,
Secretary of Agriculture.

THE IMPROVEMENT OF CORN IN PENNSYLVANIA.

BY DE WITT C. WING.

Pennsylvania produces, in round numbers, about 25 million dollars' worth of corn annually on about 1,500,000 acres. In 1903, the area planted to corn was 1,456,655, which produced 45,447,636* bushels (or 31.2 bushels per acre), valued at $25,905,153. The average yield is only one bushel less than in Illinois for the same year.

That the acreage devoted to corn in Pennsylvania can be increased to advantage to the farmers of the State seems evident. That the yield per acre can be materially augmented is indisputable. Every corn-grower in the State ought to increase his yields if he is growing less than 60 bushels per acre. Even that output is too small.

There are two ways to increase the yield: One is by planting more acres; the other is by growing more corn on the same acreage.

Larger yields depend on good seed, good soil and rational cultivation. By supplying these it will be possible to make corn-growing more profitable than it ever has been before.

A yield of less than 60 bushels per acre ought not to satisfy any grower. Pennsylvania's average could be elevated to this point if its growers would do their best by the crop. More corn can be profitably utilized in the State than is at present grown within its borders.

As a corn state, Pennsylvania ranks lower than it should. It has the climate and the soil which make easily possible its attainment of a much higher rating. It is hoped that the data presented in this bulletin may be of assistance in this direction.

While Illinois has been made the basis of much that is contained in this bulletin, the general principles involved are applicable wherever corn is extensively grown.

ORIGIN AND HISTORY OF CORN.

Southern Mexico is no doubt the original home of what we in America will always call corn, not "maize." Like many other agricultural plants, the history of its origin and development is very incomplete, and it therefore is impossible definitely to fix the place

*U. S. Department of Agriculture Year Book, 1903.

of its first appearance; yet, as Harshberger says,* the evidence of archaeology, history, ethnology and philology points to Southern Mexico as the primal habitat of this great New World cereal.

Corn is a word of Latin origin which, in America, is understood to mean corn or maize; but in Europe it is a generic term which may apply to wheat, oats, barley, rye or other cereals. In the Bible, the word corn undoubtedly is used with reference to all the grain crops harvested by the Israelites. There is no evidence that the crop we designate corn was known to any country in the Eastern Hemisphere until after the discovery of America.

In occidental history, corn usually is called maize or Indian corn. Maize is etymologically derived from the word *mahiz*, which was the name applied to corn in Hayti when Columbus landed on that island in 1492.

That corn was grown in North, Central and South America centuries before the discovery of the New World, there is scarcely any doubt. It is unquestionably a plant of very remote antiquity, and its early distribution seems to have been coincident with the wanderings of the nomadic Indians. It was the Indian's food, and so highly prized by him that he required his squaw to cultivate the crop according to the crude methods of tillage then in vogue.

From its tropical home in Southern Mexico, corn was introduced into South America, where it was grown in Chili, Peru and other countries in prehistoric times. It was no doubt grown more extensively in South America and earlier introduced there than in North America, as among the ruins of Peru are stone carvings of ears of corn executed centuries ago.† Corn may have been indigenous to South America, however, as seems probable from certain historical data, and hence may have been grown in that country as early as it was in Mexico.

Just what course corn followed from Mexico to the shores of New England, where large fields of it were found by the Puritans in 1620; to Eastern British America, where in 1535 Cartier saw extensive fields near the present city of Montreal (then called Hochelaga), and to Florida, where it was found in abundance near Tampa Bay in 1528, can only be conjectured. It may have followed the coast or passed through the intervening country. The fact that it was found in Illinois in 1679, would seem to indicate its passage through the territory lying between its native home and the remote regions to which it was introduced by the roving Red Men.

During the settlement of the country, corn became widely distributed. Columbus introduced it into Spain, whence it spread sporadically over continental Europe and parts of Africa.

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*J. W. Harshberger: "Maize: A Botanical and Economic Study," p. 151.
†C. S. Plumb: "Indian Corn Culture," p. 8.

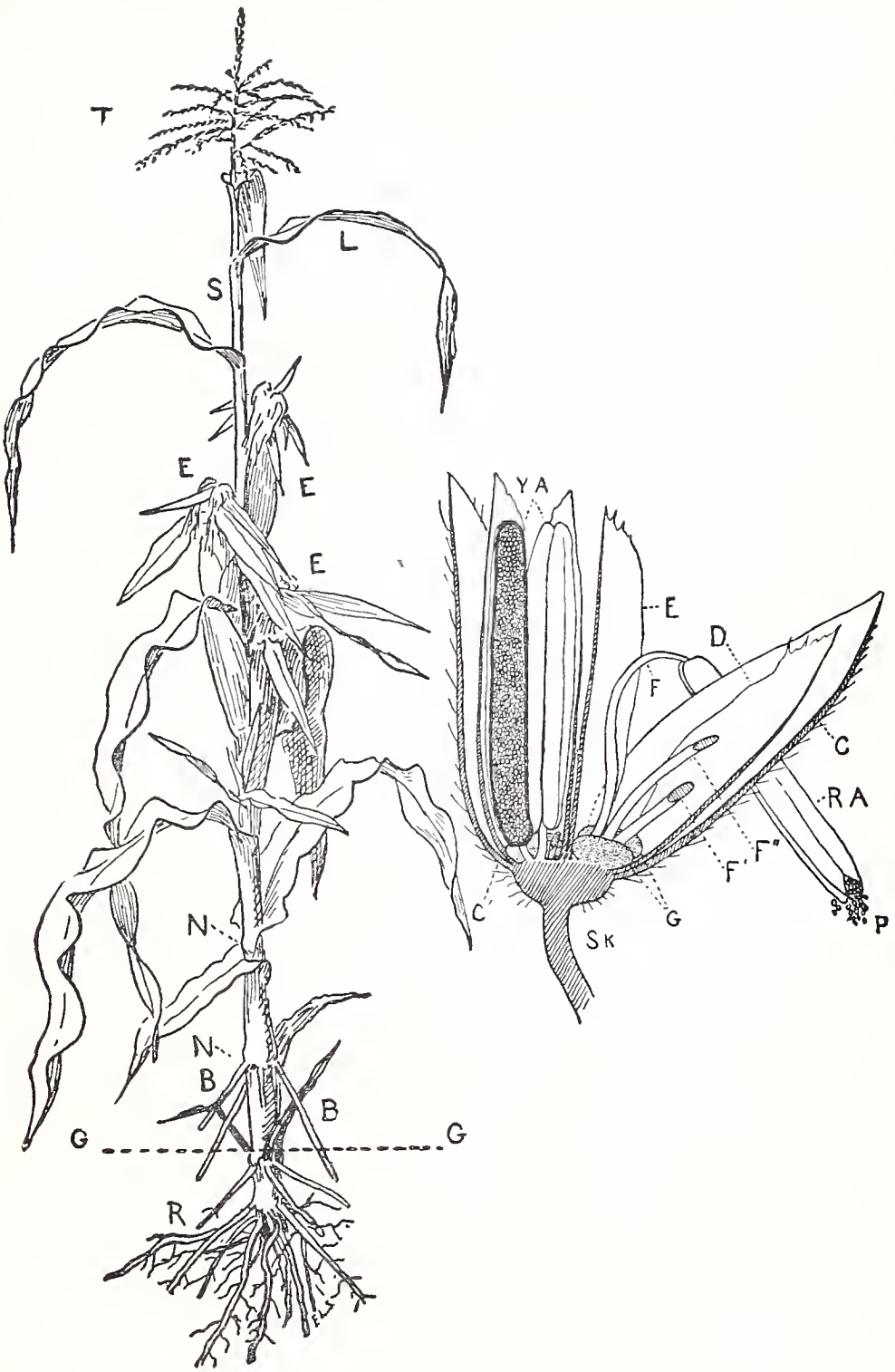

Fig. 1. A corn plant at tasseling time.

T, tassel; S, stalk; L, leaf; E, E, E, ears; N, N, nodes; B, B, brace roots; R, earth roots; G, G, surface of ground. The illustration to the right shows a spikelet cut lengthwise to expose its two flowers: the one on the right fully open, the other not yet mature. Sk, stalklet; C, C, outer bracts; D, E, inner bracts of the open flower; G, lodicules, which by swelling spread the bracts apart; F', F", filaments cut across; F, filament bearing ripe anther (R A) shedding pollen (P); Y A, young anthers, the left hand one cut to show the pollen. Enlarged. (After Sargent.)

Whatever the exact facts, which we never can know, this much is certain in reference to the origin of corn: It is one of the oldest and best gifts to man.

THE BOTANY OF CORN.

Botanically, corn is known as Zea Mays. It belongs to the grass family, and hence is sometimes called "giant grass." Teosinte, a Mexican plant of the same general habits, is the nearest relative of corn, and is by eminent botanists believed to be the prototype or original wild plant from which corn is descended. In recent years teosinte has been advertised quite extensively by seedmen, and many extravagant claims made for it.

Corn differs from all grasses in that its stem or stalk is solid instead of hollow. The plants vary in height from 18 inches to 30 feet. Stalks 20 feet high are common in the fat soils of the corn-belt.

PARTS OF THE CORN PLANT.

The corn plant consists of primary and secondary roots; the stem, stalk or culm; the leaves; the flower, and the kernel or seed. Fig. 1 shows an entire plant at tasseling time with the various parts identified.

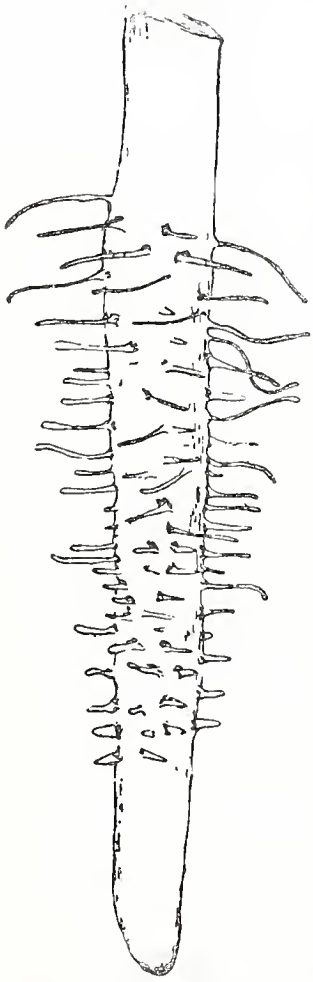

Fig. 2. A root tip of the corn plant, showing root hairs. These hairs are the feeders of the plant.

The Roots.—The primary roots are fine and fibrous, and are produced in abundance. They are the feeders of the plant. Like other members of the grass family the corn plant has no tap root. For this reason the roots branch out laterally in all directions, and in deep, dry or sandy soils considerable vertical extension is made in the search for moisture. In soils containing adequate moisture the roots grow near the surface. This explains the philosophy of shallow cultivation. Water and plant food are taken up by the root hairs with which the primary roots are provided and conveyed through them to the plant above the surface. Fig. 2 shows how a primary corn root looks under the microscope.

In a favorable season and suitable soil, corn plants develop a very elaborate root system. Roots are the mouths of the plants, as it were, and if broken the transference of food and water from the soil to the plants is prevented.

The secondary or brace roots begin to develop about the time the crop is "laid by." These grow out at the lower nodes (where the stalk is jointed), as shown in Fig. 1. Aside from aiding in holding the plant erect, these adventitious roots really have no special function. The writer has always regarded them as emergency roots; that is, they do not have any special work to perform unless an accident befalls the plant. If the plant should be blown down or partially uprooted so that the brace roots on one side were pushed into the soil they would then set about to repair the injury, sending forth primary roots from themselves and collecting water and food. It is a mistake to throw dirt toward and against the hills of corn in order to cover the brace roots; they do not require covering, and do not seem to serve any particular purpose except in cases of accident or where the surface soil is continually moist and the cultivation deep.

Suckers or tillers often develop in hills of corn. They spring from the main stem near its base. Tillering is not a variety characteristic; so far as known all varieties are addicted more or less to the habit, and the number of suckers seems to depend upon the season and the character of the soil. Each sucker soon develops a root system of its own and is capable of independent existence. Should the main plant be injured so that it could not produce seed, the sucker will make rapid growth and try itself to perform this Nature-intended work. The tillering habit in corn, however, is not desirable, as the suckers use water and food which should go to the building up of the main stalks. The elimination of this habit by breeding has been declared possible, but there are no results, complete, partial or related, which indicate that it can be done.

The Stem.—The stem attains a height of from a foot and a half to 30 feet. It is composed of smooth sections or internodes ranging in length from a few inches to more than a foot, depending on the race. These are joined together by thick joints called nodes. The internodes are flat or slightly hollowed out on the side where the leaf is grown. Some varieties produce two to six ears to the stem. Stems of corn grow very rapidly under auspicous conditions. An increase in height of four inches in 24 hours is common. The pith of the stem serves a vital purpose during the growth of the plant.

The Leaves.—From 12 to 18 leaves, varying in width from two to five inches, are found on mature corn plants of the dent varieties. Part of the leaf is called the sheath, which enfolds a portion of the stem. The leaves exhale and inhale; they are the laboratory of the plant, taking food (carbon dioxide) through their pores from the air and with the aid of the sun working it into plant tissue. This complex process is induced by the action of the sun on the chloro-

phyll or green coloring matter the leaves contain. The leaves are the most valuable part of the plant, aside from the ear, for feed.

The Flower.—The tassel is the male and the silk the female of the corn plant. Pollen grains are produced by the tassel, from 18 million to twice that number being developed by a healthy tassel. These grains contain live germs which when coming in contact with the female parts or ovules fertilize them, and thus make possible the grain. Silks are hollow and their ends, which protrude from the husk, are hairy (under the microscope). This enables them to catch pollen grains more readily which fall upon them from the air. At the end of each silk on the future cob is an ovule to which the male germ is transferred through the silk tube; the two germs thus brought together merge and form a kernel. This act is called fertilization or pollination.

THE CORN-BELT.

In the early agricultural history of the United States, and, in fact, down to within the past decade, the so-called corn-belt, still arbitrarily defined, included the states of Illinois, Iowa, Missouri, Nebraska, Kansas, Indiana, Ohio and Wisconsin, and portions of several other states. While remunerative crops of corn were grown in different sections of many other states, the corn produced in those named constituted a very large percentage of the total yield each year.

It was this consideration which suggested the application of the name corn-belt to the great corn-growing section. For similar reasons other parts of the country have been designated as the cotton-belt, the winter wheat-belt and even the bean-belt.

The present corn-belt, if defined on the basis of corn production, is much larger than when, chiefly for convenience, it took the name, and it still is expanding. Corn is grown in every state and territory, and the area devoted to it in regions which a few years ago were regarded as outside the belt steadily is increasing.

The geographical growth of the corn-belt has been made possible by irrigation, improved methods of tillage and the development of early-maturing varieties of corn suitable for Northern short-season countries. Nevertheless, it is evident that the corn-belt has its limitations, at least so far as its northerly course is concerned. Climatic conditions are such that it is not likely to become a reliable crop further north than Central Minnesota, although it may be grown with success still further toward the land of ice. It is a dependable crop in several provinces in Ontario.

The great bulk of the crop will probably always be grown in the Mississippi Valley and a few other states. Pennsylvania, undoubtedly, will continue to contribute generously to the total output, as

also will a number of the Southern states. Not only may the acreage be expected to increase materially in many sections of the country where corn is comparatively a new crop, but by using better seed and practicing rational cultivation farmers will be able to secure larger yields where the crop has been grown for a half century.

Owing to the great and increasing number of uses to which corn may be put and the limited territory in which it can be grown profitably, the conclusion seems justified that the day of what was called cheap corn (as when it was burned in Kansas for fuel) has gone never to return. Corn-growing in future, therefore, promises better financial returns than ever before. Over-production of this cereal is now almost impossible to imagine. There are many outlets for maximum crops in succession, and it is highly probable that consumption will always keep ahead of supply.

IMPORTANCE OF THE CORN CROP.

According to that philosophical and trustworthy historian, John Fiske, it was corn used for food which, almost alone, enabled the colonists to survive during the winters of their early residence in the New World. He believes that to corn we owe a national debt of gratitude.

Corn has contributed prodigiously to the prosperity and advancement of American agriculture, and thus has helped to give this country a commercial prestige which is the envy of other nations. It is the foundation of our giant live stock industry. It makes meat and wealth. It is good food for man or beast.

No crop has figured so prominently in our early history and modern commercial affairs as corn, the king of American cereals. It is the staff of our animal husbandry, and fills a niche to which no other crop is so well adapted. The yield of corn each year in the United States bears an exceedingly intimate relation to our national as well as individual weal. A widespread failure of the crop would be felt keenly in all avenues of industry and would help mightily to bring on "hard times."

While corn is now used extensively in the manufacture of many different kinds of popular and wholesome foods for human consumption, it is as a fattening material for farm animals that its largest value is realized. Americans are meat-eaters, and we produce the best quality of beef, pork and mutton in the world because we have in our immense corn crop the best material out of which to make superior meats.

In round numbers, the United States produces 2,500,000 bushels of corn annually, in a favorable season. Iowa, Illinois, Kansas, Nebraska, Missouri, Indiana and Ohio are the principal corn-grow-

ing states. Most of the crop is used in feeding live stock either by the growers on their own farms or by professional feeders who purchase the shelled grain in carload lots.

As a fattening food for cattle, sheep and swine, corn, owing to its high starch content, stands without an equal. It is not so desirable as some other concentrates for producing growth, the common varieties containing only a relatively small percentage of protein, but feeders have demonstrated, and experiment stations proved, that for the production of rapid gains, no food equals corn fed in proper combination with nitrogenous roughages. In Kansas the combination of alfalfa hay and corn makes a cheap and wonderfully successful ration for fattening cattle.

Thus it will be seen that corn enters into our material prosperity as does no other grain crop. It has come to be termed the barometer of trade, its supply influencing not only the farming operations of the country, but many other branches of business remote from, and seemingly having no connection with, corncribs.

It was a Kansas statesman, the late John James Ingalls, who, some years ago in a charming apotheosis of blue-grass, adequately expressed the importance of this "mantel of conquest," as Bailey happily has termed it; and, living in the midst of a rich maize country, it is matter of regret that the same bizarre genius, with his rare gift of felicitous versatility did not attempt to exalt to its proper place the great American "giant grass."

Corn is organic gold, the richest treasure of the cultivable soil, the heaviest creditor of American agriculture. Rightly grown and used it is the farmers' best crop-friend. But it is both a benefactor and a robber. It draws lavishly upon the plant food of the soil and, unless the farmer restores equivalent amounts of the elements appropriated, his soil gradually will be impoverished. Many a good farm has been sold in the form of corn, as witness the derelict lands in certain sections of New England. Corn then is a crop that is capable of conferring wealth and of taking wealth.

THE USES OF CORN.

Corn is now used in the manufacture of a large variety of products. The grain, cob, husks, stalk and leaves are each devoted to some useful purpose. Following is a list, complete so far as the writer is aware, of the products now being made from corn without the use of any other component material. The number of articles of commerce that are now made from corn has reached twenty-nine. Glucose sugar refining companies alone manufacture this number of products, and the number of bushels of corn consumed annually by these factories in the United States reaches far into the mil-

lions. Smokeless powder, which has come into extensive use, is manufactured by the aid of distilled spirits made from corn. The list is affixed:

Mixing glucose, of three kinds, used by refiners of table syrups, brewers, leather manufacturers, jelly-makers, fruit preservers and apothecaries.

Crystal glucose, of four kinds, used by manufacturing confectioners.

Grape sugar, of two kinds, used by brewers principally, and also by tanners.

Anhydrous sugar, used by ale and beer brewers and apothecaries.

Pearl starch, used by cotton and paper mills.

Powdered starch, used principally by baking powder manufacturers and also by cotton and paper mills.

Refined grits, used in the place of brewers' grits, and give better satisfaction.

Flourine, used by mixers of flour without detriment, except as to the feeling that a corn product is taking the place of a wheat product.

Four kinds of dextrine, used by fine fabric-makers, paper box-makers, mucilage and glue-makers, apothecaries and many industries requiring a strong adhesive agent.

Corn oil, used by table oil mixers, lubricating oil mixers, manufacturers of fiber, shade cloth manufacturers, paint manufacturers and in many similar industries where vegetable oils are employed.

Corn oil cake, gluten feed, chop feed and gluten meal, all cattle feeding stuffs of a high grade.

Rubber substitute, a substitute for crude rubber, and very extensively used.

Corn germ, the material from which the oil and cake are obtained.

British gum, a starch which makes a very adhesive medium, and is used by textile mills for running their colors, as well as by manufacturers who require a very strong adhesive which contains no acid.

Granulated gum, which competes with gum arabic, is used successfully in its place, and finds a ready preference by reason of the absence of any offensive odor.

Of course one of the principal uses of the grain, is that made of it by distillers in the manufacture of alcoholic liquors. Large quantities of corn oil are used in the manufacture of soft soap in foreign countries. It also is used as an adulterant of olive oil. Pure corn oil is generally regarded as superior to the ordinary olive oil.

Fiber is manufactured from the shell or outer portion of the stalk, while the inner portion or pith is ground and made into a product called cellulose, which is used in packing the coffer-dams of warships. Pyroxline varnish is also made from the shell of the stalk. The other portions of the stalk and the leaves are ground and prepared for stock and poultry food. The husks are utilized in the manufacture of mattresses. The cobs are turned into cob pipes, and by process of fermentation, vinegar also is made from the cobs.

It is unfortunate that farmers, as a rule, do not make more thorough use of the corn plant on their farms. More than one-third of its food value is allowed to go to waste on many farms where the stalks are burned.

CORN BREEDING.

It has been demonstrated that corn can be improved in its physical characteristics and changed in its chemical composition by selecting seed in the one case according to score card requirements and in the other according to chemical analyses, or very close physical examination. The paramount object in both cases is to enhance the value of the crop to the farmer.

Home-grown seed is often preferable to that secured from remote growers, and the writer would not encourage the purchase of large quantities of seed by any one who can obtain a dependable grade from his own fields or cribs, but as this cannot always be done it is best to buy a few bushels of improved seed. Otherwise any variety which has been grown for a considerable number of years in a given community, and thus has become adapted to the conditions prevailing therein may be used.

By examining a few ears of the nondescript corn likely to be found in his cribs, and studying it in the light of a standard of perfection, the farmer quickly will see wherein it could be improved. He will no doubt find that the ears average short, lack size and do not shell out as much grain to cob as might be desired, indicating not only a deficiency in circumference and length, but also shallowness of kernels. Here then is excellent foundation material for breeding operations.

Unless he desires to buy seed corn, which is often advisable when it can be got near by, let the farmer who has not already made his selection in the field at the time of husking, pick out in his crib the best ears obtainable, having previously determined the type which he desires to perfect, and place them where they will be safe from mice and rats. Generally speaking, it is advisable, the plant breeders tell us, to select ears from 10 to 11 inches long and from 7 to 8 inches in circumference, with deep kernels and well-filled tips and butts.

Theoretically, the type of the seed will be reproduced in the resulting crop, this being predicated on the familiar law that like produces like; but corn that has been grown without effort to keep it pure or improve it will require several years, according to the dictum of plant breeders, to decrease its potent tendencies toward marked variation even under soil conditions regularly identical, so far as this status is possible. For this reason the first crop from the carefully selected seed will probably show a very large majority of ears classifiable as "off type." It is likely, therefore, that the grower, entertaining rather too extravagant a hope, will not regard the crop as any better or more uniform in type of ears than the one from which the seed was selected; but if he persists in picking seed ears according to the same rules, and plants the corn at least 60 rods away from any other field of a different variety of corn, results up to expectations surely will come—if we may judge the future by the past.

By unswerving adherence to type in the selection of seed the tendency to vary in a given locality will be reduced, and greater uniformity result. This is the verdict of much experience. It is impossible entirely to eliminate this valuable tendency, but it can be controlled in larger measure after years of unmixed breeding than before. Breeding for a type strengthens dominant characteristics and makes for uniformity. Every corn-grower ought to have a particular use for his corn. If he had, then he could breed corn for it. Well might Dr. Hopkins' admonition be universally heeded. He says: "Breed corn for a purpose. If you wish to feed corn, breed and grow high protein corn. If you wish to grow corn for the starch and glucose factories, breed and grow corn the factories want."

Marked results are possible in course of time if proper precautions are taken to prevent, as far as possible, the fertilization of the breeding corn by the pollen from a scrub or different variety. Where it is inconvenient to isolate a breeding plot, a satisfactory plan is to plant the best seed ears in the middle of a large field of the same variety. Each year's seed should be selected from this protected plot. This method makes it difficult for aerial pollen from neighboring fields of mongrel corn to fertilize the breeding plants, as the surrounding corn is likely to intercept the pollen grains carried by winds.

Corn breeding, in its final analysis, is simply a rigid process of seed selection. If the same type and color of ears are selected year after year, improvement in certain physical characters will follow, and the grower will note with satisfaction that while a hundred ears picked at random will not be identical—a condition im-

possible to secure—they will nevertheless show more uniformity than an equal number representing the original seed. Any farmer may be said to be a corn breeder who takes pains each year to secure the same type of ears for seed. This is the whole philosophy of corn breeding. On this basis all recorded work in corn breeding has been done. It reduces the process almost to a science.

PHYSICAL IMPROVEMENT.

Corn has been grown in America ever since, and centuries before the country's discovery; it has been systematically bred for only about 10 years. While farmers here and there nearly a half century ago were carefully intelligent in the selection of seed, as fragmentary history reveals, and perhaps grew many ears that would compare favorably with well-bred specimens of the present time, the effort to improve the cereal was not orderly nor general.

It seems never to have occurred to early-day scientists that corn, like animals, could be improved by breeding or selection, although the improvement in the chemical composition of the sugar beet through selection furnished many years ago an illustration of the possibilities of plant breeding. There was no such thing as conscious corn breeding until late in the last century, when the subject began to attract attention in the Central West through the work of James L. Reid and H. B. Perry, of Illinois; James Riley, of Indiana, and the Leamings, of Ohio, and a few other growers who effected marked improvement in certain varieties by persistently selecting superior seed for each year's planting.

In Illinois, early in the '90s, interest began rapidly to grow in the exhibition of corn for prizes at county fairs, farmers' institutes and the State fair. A score card or scale of points soon followed, and corn judging assumed the aspects of an art. Strong emphasis was placed on the physical characteristics of ears and kernels, and until within the past two years more importance was attached by some breeders to the shape and individuality of the ear than to its productivity. But knowledge of the desirable points of corn led to systematic attempts to reproduce the coveted physical characters. Like animal breeders, the cornmen began their work on the basis that like produces like. Following this well-established law they used for seed only those ears showing the characteristics sought, and thus inaugurated a process, based on intelligent seed selection, which, during its brief operation, has wrought marked physical amelioration in certain varieties of corn.

To evolve heavy-yielding corns is now the chief concern of the more progressive seed corn-growers, who a few years ago were intent upon producing typical ears that would score high or win

prizes at corn shows. The commercial side is now uppermost in corn breeding.

For several years after corn breeding began to receive attention at the hands of idealistic growers, the prime object was to produce an ear from 10 to 11½ inches in length, from 7 to 8 inches in circumference, cylindrical in form or shape, with perfectly-filled tips and butts, straight, close-set rows of deep, wedge-shaped kernels, the ear shelling from 85 to 90 per cent. corn to cob, according to the method of determining this point. Yield was more or less a secondary consideration; appearance was more important.*

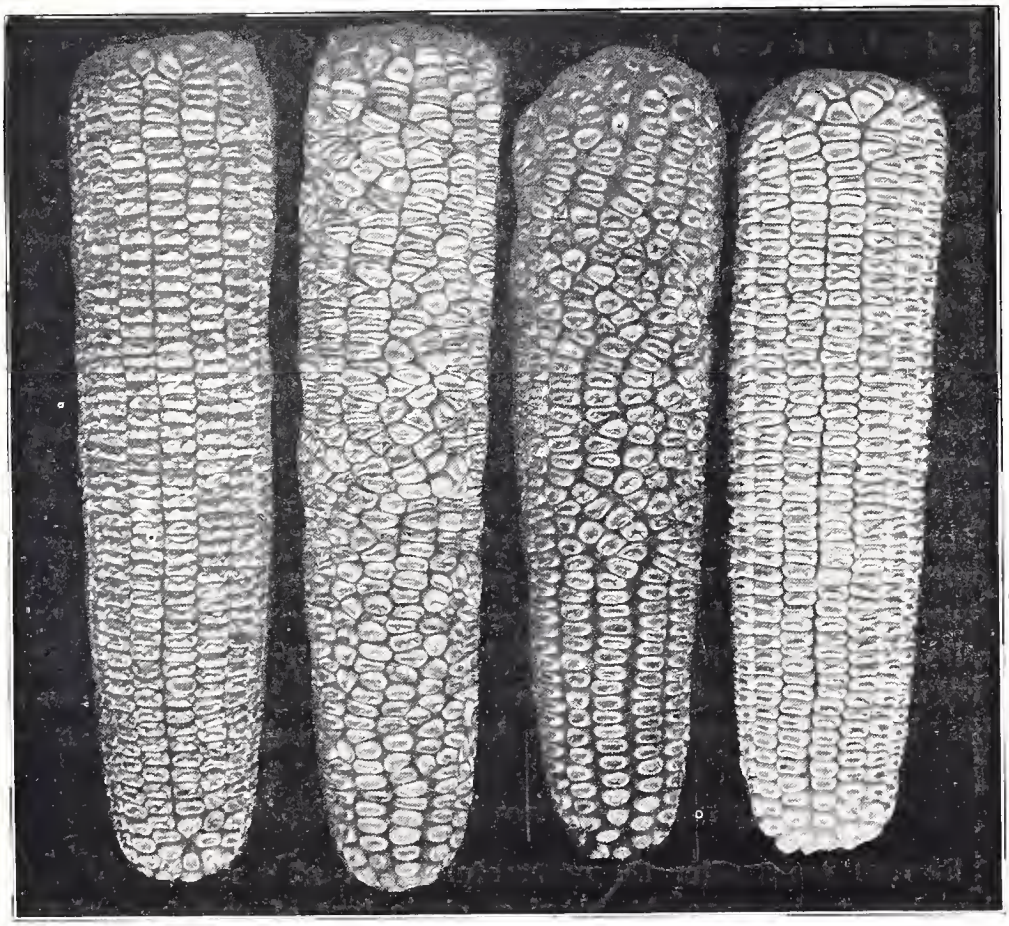

Fig. 3. Ears lacking uniformity and showing different characteristics.

While much impractical and purely esthetic corn breeding work was done in unprofitable ways, it served the useful purpose of demonstrating the susceptibility of corn to physical improvement, and the result has been the generation of an infectious, wholesome interest among corn-farmers in what is now commonly termed pure-bred seed. Formerly the average corn-grower would probably have used all the ears for seed shown in Fig. 3; now he would

*The Breeder's Gazette, Dec. 7, 1904.

reject the two middle ears and possibly the ear shown at the left in the cut.

Perhaps of the three or four old-established, distinct breeds of corn, Reid's Yellow Dent is the best illustration of what can be accomplished by using sound seed that has been carefully selected with a fixed, definite object in view.

Only a few growers addressed themselves to the breeding of corn during that period when the work was passing through the experimental stage; but after results were obtained which demonstrated the general theory of the plant breeders, large and increasing numbers of farmers, appreciative of the commercial opportunities inhering in the work, began to engage in it. If plant breeding had done nothing more than induce greater care and better judgment in the selection of seed corn it could be chronicled as one of the most valuable developments in the field of agriculture. But it has done much more; it has paid. It has made thousands of practical farmers actually difficult to please in the matter of farm seeds of all kinds. This is a monumental blessing to agriculture.

Those who have made corn breeding a study and been successful in intensifying desirable, and minimizing or eliminating objectionable characteristics, believe that what has been done is insignificant compared with what confidently is expected to result from a continuation of the same methods of procedure now in vogue. But in the future the commercial phases of the work will govern it. Corn that will shell the largest percentage of grain to cob or "weigh out" the best is what breeders are now trying to evolve, many of them manifesting indifference toward the purely fancy points which a few years since were unduly magnified. Utility or practical value will be the motive of corn breeding henceforth. This is as it should be. Fig. 4 shows specimen ears that are the result of improvement.

CHEMICAL IMPROVEMENT OF CORN.

Several years after the successful efforts of a number of corn breeders to improve the physical characters of certain varieties were made known, and following the general awakening of interest in the subject of corn amelioration, Dr. Cyril G. Hopkins, of the Illinois Experiment Station, made a thorough study of the chemistry of the corn kernel, ascertaining its composition and finding that, while different ears of a given variety vary in respect to their chemical composition, the different kernels of a single ear are fairly uniform in composition.

Up to that time the sugar content of the sugar beet had been increased from about 5 per cent. to 16 per cent. through the process of selection based on chemical analysis. This remarkable work

suggested to Dr. Hopkins the idea of effecting changes in the chemical composition of corn, the impelling motive being to increase the value of the cereal for different specific purposes.* For example, it was known that an increase in the protein content would add to the value of the corn for feeding to growing animals or for manufacture into corn flour for human food. It also was known that an increase in the percentage of carbohydrates would render corn more valuable to the manufacturers of starch, glucose-sugar, syrup or alcohol, and that a larger oil content would be of special advantage in fattening stock.

In 1896, Dr. Hopkins undertook the new and wholly original work which to-day ranks as a classic in American agriculture. At that

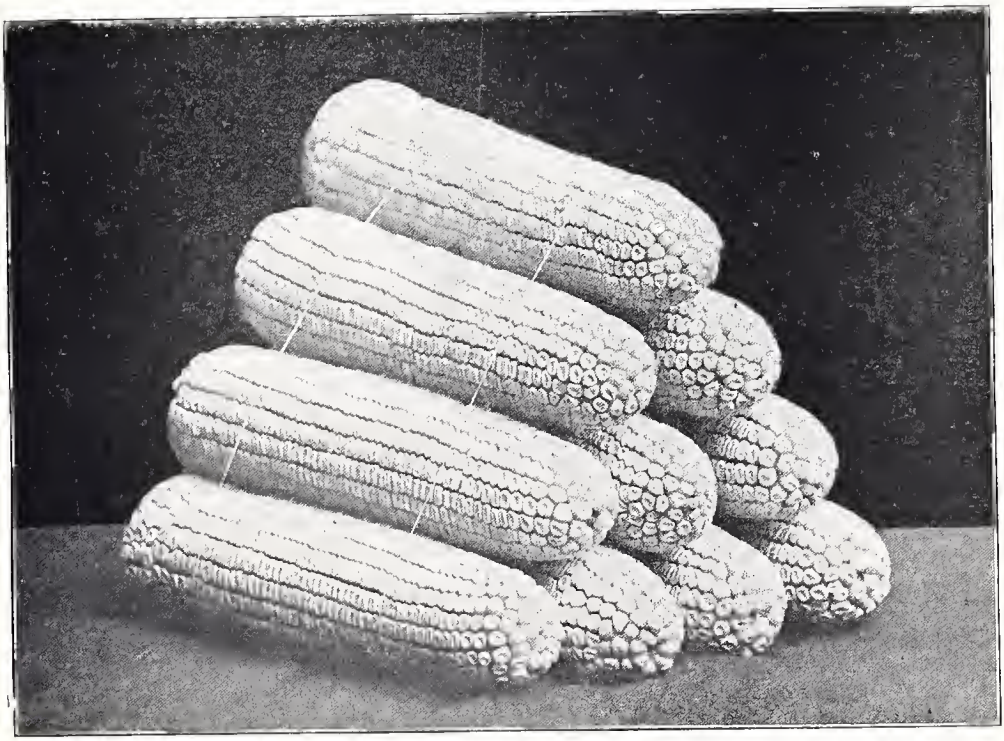

Fig. 4. A sample of Silvermine ears grown from improved seed, showing uniformity and well-filled tips, and illustrating the effect of breeding.

time he instituted separate experiments to increase and decrease the protein content and to decrease and increase the fat content of a variety of white corn locally known as Burr's White. A number of kernels from each of several hundred ears of this corn were analyzed chemically and the approximate composition of the ears determined. Those showing the highest or lowest percentages of the constituents which it was desired to increase or decrease respectively were used for planting. Complete records were made

*Bull. No. 55, Ill. Expt. Station.

of all analyses. Each ear selected on this basis was used for planting one row. If, for instance, there were 21 ears selected for increasing the protein content, 21 rows were planted, the length of the row being sufficient to require nearly all the kernels on the ear. The ear showing the highest percentage of protein was planted in the middle row of the plot, and the other 20 ears were planted in approximately uniform gradation to either side.* In order to guard against cross-fertilization, breeding plots were selected remote from fields or other plots of corn or located in large fields of the same variety.

From the crop following this planting the best ears were selected, and two rows of kernels from each chemically analyzed as before. Comparing the statistical results with those obtained in analyzing the original ears, it was found that, in the aggregate, appreciable alteration had been effected in the desired direction. From the first year's work the results were sufficiently marked to indicate the possibilities of persistent work along the same line, and, as the appended table will show, the changes grew more pronounced as the work progressed. The table shows the increase and decrease in protein, one plot being devoted to high protein and one to low protein, together with the difference in composition for each year beginning with 1896:

Year.	Per Cent. of Protein in Crop.		
	High oil plot.	Low oil plot.	Difference.
1896,	10.92	10.92	.00
1897,	11.10	10.55	.55
1898,	11.05	10.55	.50
1999,	11.46	9.86	1.60
1900,	12.32	9.34	2.98
1901,	14.12	10.05	4.07
1902,	12.34	8.22	4.12
1903,	13.04	8.62	4.42

Ear highest in protein, ... 17.33 per cent.
Ear lowest in protein, ... 6.37 per cent.

The high protein column shows that the increase in that compound, which gives a better balanced ration than does ordinary corn, has been gradual and uniform, except for the year 1901, when a striking increase was made. Reference to the low protein column for the same year will show a pronounced increase instead of decrease of protein. Dr. Hopkins informs the writer that these peculiarities are due to the fact that 1901 was a "high protein year." It

*Bull. No. 82, Ill. Expt. Station.

was abnormal, being very d y, which greatly reduced the formation of starch in proportion to the formation of protein. The year 1902 also is referred to as an unusual season, favoring especially the formation of starch and reducing protein formation. A gradual diminution of protein from 10.92 per cent. in 1896 to 8.62 per cent. in 1903 is shown in the column for low protein. By decreasing this constituent, the proportion of starch is correspondingly increased; consequently low protein corn is of special value to starch factories.

An experienced judge of corn, from a careful physical examination of kernels, can pick out the high protein specimens, being able easily to distinguish them from the low protein kernels by their larger amount of hard, horny, translucent material and their smaller hearts or germs. It is necessary to cut the kernels into cross sections as they are cut. This gives an idea as to relative proportions of protein, starch and oil. A high protein kernel is shown in Fig. 5; a low protein kernel is seen in Fig. 6.

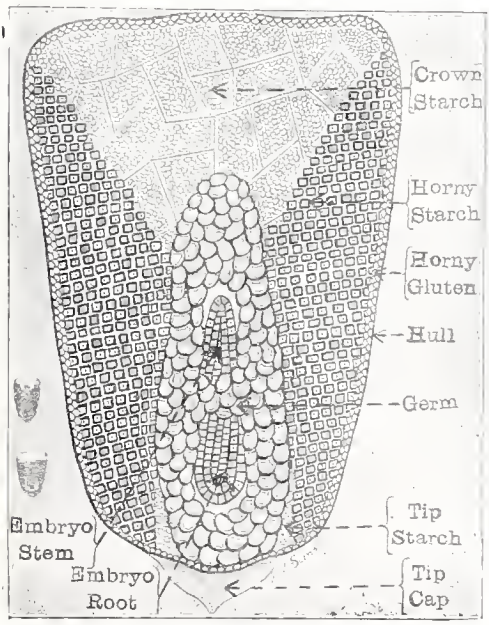

Fig. 5.

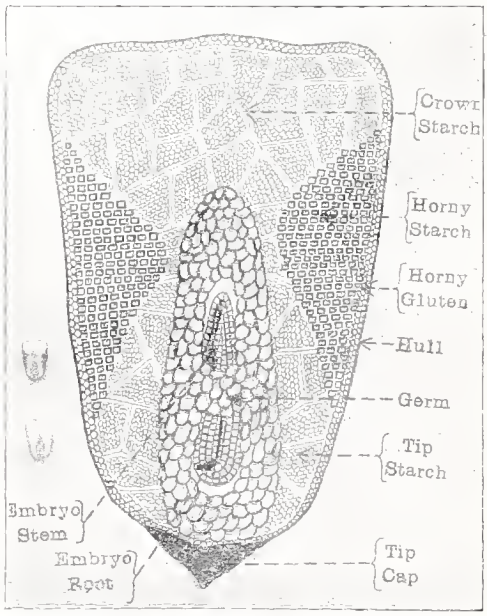

Fig. 6.

Fig. 5. A high-protein kernel, showing at either side a large amount of horny gluten indicated by the dark squares.

Fig 6. A low-protein kernel, showing a preponderance of starch and considerably less horny gluten than Fig. 5. (Illustrations, Figs. 5 and 6, loaned by Dr. Cyril G. Hopkins, of the Illinois Experiment Station.)

By selecting for seed kernels with very large hearts, the oil content can be increased; by selecting kernels for seed that have a relatively thick layer of hard, horny material next to the hull, principally in the edges and toward the tip end of the kernel, as shown in Fig. 5, the protein can be increased; by selecting for seed

those kernels which show a relatively small amount of this hard material the starch content can be augmented. It, therefore, will be seen that chemical improvement can be made in corn without chemical analyses, seed selection being based entirely upon physical appearance. However, one must know the corn kernel thoroughly in order to prosecute this work successfully.

The subjoined table shows the increase and decrease of oil in corn effected by Dr. Hopkins:

Year.	Per cent. of Oil in Crop.		
	High protein plot.	Low protein plot.	Difference.
1896,	4.70	4.70	.09
1897,	4.73	4.06	.67
1898,	5.15	3.99	1.16
1899,	5.64	3.82	1.82
1900,	6.10	3.59	2.51
1901,	6.09	3.43	2.66
1902,	6.41	3.01	3.40
1903,	6.53	2.97	3.56

Ear highest in oil, ... 7.71 per cent.
Ear lowest in oil, ... 2.12 per cent.

Several glucose factories will pay a premium for high oil corn, while low oil corn is desirable for certain feeding purposes. Last year one or two growers offered high and low oil corn for sale. The writer would not advise the purchase of this seed in large quantities until it has been bred higher or lower in the desired direction.

In recent years experiments to change the chemical composition of corn have been conducted on an extensive scale and in coöperation with corn-growers in different sections of Illinois, so that Dr. Hopkins has been able to make the work of commercial advantage to the farmers of the State. Pennsylvania farmers who might desire to engage in this line of corn breeding can no doubt secure assistance from the chemists at the University of Pennsylvania and State College. It would seem advisable, however, for the farmer to leave such work to the experiment stations or seed corn specialists, as, unless it is carried on with special care and accuracy, and under proper conditions, the results may not pay for the time and labor involved. Breeding corn to alter its chemical composition is tedious work which very few farmers, capable though they may be, have the time or inclination to undertake. It is exacting and complicated.

Some good types of corn are fortunate enough to have as many as twenty different names, but those who have conferred the names, of course, stoutly deny the oneness of their so-called distinct varieties, each claiming his to be "different." It cannot be gainsaid that in many cases there is some ground upon which to base the claim of distinctness. For example, a Pennsylvania farmer might this year plant a bushel of what, in Illinois, we call Reid's Yellow Dent and five years later call its posterity Jones' Golden Wonder, the change of location and the resultant adaptation of the corn to its environment altering its type or at least certain characteristics to a degree warranting another name.

So unstable are the characteristics of any variety of corn that, when transferred from one region to another many miles distant, its nomenclature is, and perhaps for many years will remain, in a chaotic state. More than 1,000 names are in use, but there is of course not an equal number of different or distinct types of corn. Names of corn, as a rule, are not known except in limited regions. If Boone County White (originated in Boone county, Indiana), for illustration, were grown in Lancaster county, Nebraska, for a few years, it would undergo physical transformation which would probably give rise to another name.

There ought to be as many names for corn as there are varieties which are unfailingly true to type. Boone County White ought to be known by that name wherever it is grown. To change the name of a variety because it undergoes a few alterations, rendering it unlike the original seed ears, is as reasonable as for Brown to call himself Smith simply because he does not resemble his father. He is a Brown even if he does not resemble his father in any feature or characteristic. Therefore, corn descending from any well-known variety, such as Leaming, Reid's Yellow Dent, Silvermine, or Boone County White, should retain the name of its ancestor.

New names serve to deceive those who buy seed corn; for no other purpose are they useful. Change in any characteristic may give rise to a new name. To illustrate: If a Kentucky corn grown for years in that state were introduced into Wisconsin, it would, in a few years, materially shorten its original period necessary to mature its grain. If it matured in about 125 days in Kentucky, it would probably shorten this period by 20 or 30 days after several years' culture in Wisconsin, where the vernal season is much shorter than in Kentucky. This would not entitle it to a new name. Shipped back to Kentucky, the same corn would readjust itself to its then new surroundings, and in due course would require its original 125 days for complete development.

Each state in which corn is largely grown should have a corn-growers' association. Several commonwealths already have active, useful organizations of this character. It should be the business of these societies to evolve a system of nomenclature and see to it that the necessary rules and regulations were enforced.

In Illinois the corn-growers' association recognizes only seven varieties of corn as distinct; alleged varieties not so recognized are of course at a disadvantage when competing with the standard corns for popular approval. Members of the association—and it has a very large and growing membership—do not use other names than those which have been adopted for the seven breeds of corn. These corns are as follows: Reid's Yellow Dent, Golden Eagle, Riley's Favorite, Leaming, White Superior, Silvermine and Boone County White. For each of these a standard of perfection has been formulated, differing only in certain points. These standards are subject to change by vote of the membership of the association. Many so-called new varieties of corn are constantly being tested, but in the majority of cases are found to be almost identical with or confusingly similar to some of the standard varieties. For this reason they fail of place on the list with "the lucky seven," as one grower has facetiously remarked. They are regarded as modifications of the recognized corns. Occasionally, however, a corn under test shows distinguishing characteristics. It is grown for several years to determine the fixity of the characters, and if the association is sufficiently impressed with the results, the matter of its acceptance is taken up and discussed. So far, the association has not increased its original list of seven varieties. Pride of the North is one of the varieties which has been considered for membership at several sessions, but it is yet outside.

Detailed descriptions of all the recognized breeds of corn are published, along with other matter distributed among the membership by the association, and this information is given wide publicity in various ways, including the agricultural press. But as the majority of farmers who grow corn are not members of the association, they do not receive the information distributed by the organization. Moreover, as they are not familiar with corn judging they do not derive a great deal of benefit from reading about it in the papers. If they were acquainted with the technical terms used in describing corn they could better understand printed descriptions. To understand the art of judging corn one must handle and study the ears critically and often.

Scores of local names are used by farmers who do not hold membership in the association; but these are ignored by the members. If the names of the unrecognized corns be used in advertising corn for sale, members of the corn growers' association cannot be de-

ceived thereby, but farmers unaffiliated with the organization, and those in other states, may be easy victims, buying the "new" corns and perpetuating the names, not knowing the corns to be identical with certain recognized varieties. This point illustrates the necessity for the organization of corn-growers into separate State associations, and the formation of a national association. Every corn-growing state should have its list of standard varieties with a scale of points for each. If such associations existed, a national society undoubtedly would spring into existence, and among the many useful functions it might perform would be the publication of the names of all the standard varieties of corn in each state, together with a detailed description and scale of points for each, the data to be printed in bulletin form and a copy sent to every corn-grower identified with a corn growers' association.

The writer believes that a scheme worked out on these lines must be adopted sooner or later in order to check the frauds being perpetrated by seedsmen who find new names so effective in selling old, well-known varieties of corn.

THE RACES OF CORN.

Botanically, there is but one species of corn, Zea Mays, but this one is divided into six distinct groups or races, each of which has many varieties, due to culture in different climes. These races have well-defined, persistent characters which admit of specific nomenclature. The six races are the Pop corns, the Flint corns, the Dent corns, the Sweet corns, the Soft corns and the Pod corns, which are thus described by Plumb in his valuable work on "Indian Corn Culture:"

Pop Corn.—The substance of the center kernels is hard and flinty (corneous) all through, excepting at the germ end, no white, soft starchy substance being present.

Flint Corn.—The corneous matter surrounds the sides and top of the kernel, so that it is enclosed in a hard, flinty coat, with soft, starchy substance in the central part. The kernel is usually about as broad as long, and rounding and smooth over the top. Flint corn is somewhat smaller than dent, and is best suited to New England and the Northern line of corn growing.

Dent Corn.—The sides of the kernel consist of corneous matter with the central part filled with soft material, even to the dented or contracted rough top. This contraction is due to shrinking of the softer part of the kernel in ripening. The kernel in many varieties is slender or wedge-shaped. Nearly all the corn grown in the great corn-belt of the Central West belongs to this race.

Sweet Corn.—The kernels consist of translucent, horny material, which contains considerable sugar (glucose) instead of starch. The

kernels in most varieties are quite wrinkled or twisted and are distinctly wedge-shaped.

Soft Corn.—Excepting the germ, the entire kernel is starchy and soft in character and has somewhat the form of the flints. This race is commonly grown in sub-tropical corn regions, as the far Southwest and in Mexico. This is the early form of the corn as grown by the Indians.

Pod Corn.—Pod or husk corn is a variety in which each kernel is enclosed in a small husk, while the aggregation of kernels, which may form a long or short ear, is enclosed in large external husks on a simple cob, as with common ears. Flint and dent corn may exist in this variety. Pod corn seed, when planted, will usually give a crop of both podded and unpodded ears.

Each variety of corn may be easily classified with one of the so-called races which were worked out by Dr. E. L. Sturtevant, according to its seed. However, if two or more races are grown close together there will be ears composed of a mixture of each class, especially if the flowers develop at the same time.

DENT AND FLINT CORNS COMPARED.

Dent corn is the most common in the Central states and is of greater commercial value than all the other races combined. It is represented by almost as many varieties as there are different climates in which dent corn is grown. This race has in Reid's Yellow Dent and Leaming two distinct and well-established types. At least three colors characterize dent corns—yellow, white and red, while red and yellow in combination constitute what is called "calico" corn. This is the outcome of crossing breeds or varieties. The cobs of dent corn are red and white, and sometimes mixed. Dent corn is the result of unconscious selection toward a type of the highest productiveness under the extremely favorable conditions of climate and soil in the corn-belt. Similarly other races have been developed by selection for certain purposes. All have their specific uses, and by breeding may be still further specialized, particularly as regards chemical composition. According to the plant breeders, any of the characteristics can be improved or modified by breeding.

The dent corns produce larger yields than any of the other races under corn-belt conditions, due to their larger number of kernels on the cob. More than 1,300 kernels frequently are produced on one ear, while the average of standard ears is probably near 1,000. Ears of these varieties contain from 12 to 24 rows of kernels and from 40 to 65 kernels in a row.

Flint corns are adapted to northerly regions and clayey soils. In color they include several shades of white. Some of the varieties are red, some blue and some yellow. Most of the flint corns

have eight rows of kernels to the cob, though some of them have 12, with from 30 to 50 kernels in a row, depending of course on the length of the ear. For roasting ears, the flint corns are generally considered superior to dent or other varieties.

For feeding purposes, dent corns are superior to all other races; but the stover of the flints, being usually less woody than that of the dents, is better for feed. For this reason it would seem that for silage, the flints would be very desirable, provided there was a sufficient proportion of grain.

THE COLOR OF CORN.

Chemically, there is on the whole no difference between white and yellow corn. Neither is red corn different in composition from either of the other colors. Color does not affect the composition of the grain or the stover. Many stockmen, however, prefer yellow corn for feeding, contending that some classes of stock eat it with more avidity than white corn. There are no recorded experimental data to support or combat this contention. None should be needed. White dent varieties, according to a summary prepared several years ago by the Mississippi Experiment Station, outyielded the yellow corns of the same race to the extent of about 2½ bushels per acre in seven different states, 217 white and 273 yellow varieties being involved. No one, however, should be led by this showing to discriminate against yellow corn on the basis of yield, as the result announced was more of an accident than a significant fact.

For meal to be used for human consumption, white corn is of course more popular than yellow corn, especially in the South (although the yellow is preferred in New England), and there are other uses which may suggest a preference for the one or the other, but in no case can the preference be based fairly on chemical difference in value.

WHAT VARIETIES TO PLANT.

What varieties to grow is a question which cannot be answered here. The most that can safely be said is that the farmer should grow those varieties which have given the best yields in his locality. Leaming has perhaps given greater satisfaction than any other dent corn grown in Pennsylvania. It is a yellow corn with tapering ears, about 11 inches long and 7½ inches in circumference and deep wedge-shaped kernels of which there are from 16 to 24 rows on the cob. It shells out well, but has a fairly good-sized red cob. The stalks grow eight to 10 feet high, depending on the character of the soil and climate, and are rather coarse. Leaming matures medium early, is very prolific and seems to be more cosmopolitan in nature than most other corns. It is said to have been originated in Hamilton county, Ohio, in 1826, by J. S. Leaming.

Of the corn-belt white dents suitable for Pennsylvania conditions the writer belives that Silvermine would be generally satisfactory. It has given good yields in a larger territory than any other white dent corn. Its origin is not definitely known, but is generally credited to Ford county, Illinois, where J. H. Beagley is said to have evolved it from seed of a white corn which won a prize at a local farmers' institute in 1890. The ears are cylindrical, about nine inches long and a little more than seven inches in circumference; the kernels, of which there are from 16 to 22 in a row, are cream white, long and tapering; the proportion of corn to cob, as given by the Illinois standard of perfection, is 90 per cent.; the cob is small and white. Silvermine is a liberal bearer, rather early-maturing, and, like Leaming, is adapted to a wide range of country. Ten ears of this variety are shown in Fig. 4. For show purposes these ears constitute the best sample the writer has ever seen. They are practically perfect specimens of the breed.

Length of ear, depth and shape of kernel and the number of rows of kernels are important points to consider in selecting a variety of corn. Productiveness is the prime consideration. The points mentioned determine in very large measure the number of bushels per acre. Ears of good size with small cobs, and proportionately long, make the most corn per acre. The use to which the corn is to be put, however, should govern the selection of the race or varieties.

As for new varieties, there is no demand for them, though some of the old sorts need improvement in certain points. Improvement is easier and promises better practical results than the origination of new corns, especially from the standpoint of the busy farmer.

PURE-BRED SEED CORN.

Notwithstanding all that has been said and written about pure-bred corn, there is not a bushel of it to be found to-day, and in the nature of things there never has been a bushel of it produced. It takes many years to establish purity in animals or plants. Live stock breeding was under way nearly 500 years before the sexuality of plants was known. It took centuries to evolve what we to-day call pure-bred live stock. When shall we have pure-bred corn? Let time answer.

To be pure-bred, a variety of corn must be absolutely free from the "blood" of any other variety. So far, it never has been possible for any grower, except in a small way, so as to control conditions that he could prevent the infusion of unlike "blood."

If plant breeders insist that corn breeding and animal breeding are analogous, they must not claim that pure-bred corns now exist, for efforts to breed corn pure have not been under way long enough to establish purity in any variety. It takes many years to elimi-

nate the scrub blood in animals to the extent that they will be accepted as pure-breds by reputable herd-book associations; yet as the mating of animals can be absolutely controlled, it is manifestly much easier to get rid of the scrub element than in the case of corn, where invisible matings of scrub pollen and ovules of improved varieties occur in spite of all the practical precautions the grower can take. This ought to be adequate proof of the statement that there is no such thing as pure-bred corn. There are, however, improved varieties of corn, and these are preferable to the unimproved corns.

Improved corn is for sale by breeders in several states, but it is not pure-bred or "pedigreed" corn. It is better than ordinary corn only to the extent that it has descended from seed selected year after year according to a high standard of excellence, and thus has acquired an hereditary force which makes it a better seed product than nondescript corn. Farmers are to be warned against the "pedigreed corn" fake. It has been worked rather diligently in recent years and many farmers have been duped. It will be many years before pedigreed corn is a reality. Corn that has been sold as such in many cases has not proved any better than seed selected from the farmer's own crib. This sort of thing has injured the legitimate seed corn industry.

High protein and low protein corns have been bred until seed is offered by some growers which may be depended on to produce more or less protein, as the case may be, than ordinary varieties, but these are not pure-bred corns. While wonderful progress has been made by a few Illinois farmers, under direction of their State experiment station, both in increasing and decreasing the protein of certain varieties of corn, the work has not been conducted for a sufficient length of time to warrant the extensive purchase at an advanced price of the corn for seed. The writer would not be understood as opposing the worthy efforts of honest growers to disseminate improved seed corn at remunerative prices. He has stated the foregoing facts frankly for the protection of farmers against an augmenting class of unscrupulous dealers who tell alluring stories in order to get orders for inferior seed. Owing to the newness of the corn improvement campaign, and the consequent paucity of general knowledge of what it means, what it proposes and what methods are employed, many farmers, unless they are forewarned, are likely to be defrauded by these cunning individuals.

A few varieties of corn are sufficiently true to type to warrant the statement that they are practically pure-bred, but they are not pure. Certain characteristics can be fixed long before absolute purity of breeding can be assured.

BUYING SEED CORN.

Unless we have implicit confidence in the seller's commercial honesty, the purchaser of seed corn should demand that it be shipped in the ear. It is easy to deceive with shelled corn, which may represent many varieties or types, even (and often) nubbins; whereas the whole ears are honest representations, and the buyer knows what he is getting.

All reputable seed corn-growers will ship corn in the ear, though they will shell it if the purchaser desires it in that form. With crates, made specially for the purpose, ear corn may be shipped long distances without appreciable mutilation, so that there really is no good reason why all seed corn should not be so shipped.

Unless he have good seed of his own growing, the farmer who has faith in well-bred corn, will do well to buy a few bushels in the ear from a reliable seedsman. Get it as near home as possible. A smaller quantity might suffice in many instances. A start can be got with a few ears.

If the seed be purchased with a view of growing from it the seed crop for the succeeding year's planting, care should be taken to keep it as pure as possible; that is, to prevent the pollen of neighboring scrub corn from fertilizing the silks of the improved corn. This involves the isolation of the latter. Where an attempt is to be made to breed corn pure from supposedly pure seed, it should be planted at least 60 rods from any other growing corn of a different variety. Even then interpollination cannot be entirely avoided. Pollen is a yellowish powder which is capable of great flights, being carried long distances by the wind.

Owing to the ease with which pollen may be transported by the wind, it is practically impossible for any one farmer in a corn-growing section to keep his corn absolutely pure unless all his neighbors also breed the same variety of corn. Alone, his work will likely be somewhat disappointing, although by using better seed he will grow larger crops, regardless of the alien blood which may get into his corn from the fields of his neighbors. About the most that can be said is that corn can be bred practically pure under farm conditions.

Seed corn in the ear costs more than shelled corn because it is worth more. No dealer or grower can afford to ship a customer inferior nubbin-like ears for seed. He knows it would be refused; yet if the seed were ordered shelled it would be a simple matter to run all sorts of ears through the sheller, grade the kernels with a fanning mill and sell the product as representing show ears. This has been done by unscrupulous dealers.

The writer would not advise any one to buy a large quantity of seed grown outside his own local agricultural zone, as it often hap-

pens that when introduced into regions climatically, and otherwise, unlike those to which it has adapted itself, corn does not "do well," to use the field vernacular. If possible get seed from growers in your own State. Soil peculiarities and climatic conditions in any one state are never identical with those of any other state. Soils differ widely even in the same county, indeed in the same field, and as the food supply and moisture have more to do than any other two factors in the development of a corn crop, this fact of different conditions should be taken into account in purchasing seed. Soil and climate will change the type more radically than selection.

One corn breeder has declared that if he were again to make a beginning in this work he would select seed in his own township and from his own supply if it were good enough. His effort then would be to bring this native corn up to the highest degree of excellence by painstaking selection of seed each year. Home-grown seed is the best, so far as its adaptability to local conditions is concerned. There is not much risk, however, in buying a bushel of seed. If it does not please, the loss is slight. Therefore, any one who decides to order corn from a distance ought to make the amount small. Perhaps a bushel will produce ample seed for the succeeding year's planting.

TESTING SEED FOR VITALITY.

Corn weak in vitality or germinating power produces sickly plants, if it germinates at all. Seed should be fresh and sound, otherwise the stand will be imperfect and the plants backward in growth. It does not pay to use an inferior grade of seed corn. To make sure that the vitality of the seed is unimpaired, at least three kernels from each seed ear should be tested, though this is not necessary where a selection of 75 to 100 ears can be made that will faithfully represent the quality and general characteristics of the entire stock from which seed is to be obtained.

Corn harvested prematurely is likely to show much loss of vitality, while frosted corn and that which has remained in the shock exposed to the weather for several weeks are sure to undergo a lessening of germinating power. As corn cribs containing the crop that has been husked from the standing stalk or from shocks are the chief sources of seed in most corn-growing sections, there is reason to believe that hundreds of bushels of inferior seed are used every year. Farmers who depend on the general cribbed supply for seed do not get the best quality of corn. It is especially important, therefore, that seed should be tested. It also is advisable to test purchased corn.

Tests for vitality are easily made. Select the kernels from different parts of the ear. Make a box about four inches deep, two feet

wide and say 30 inches long; it may be of half-inch pine boards. Cover the bottom with a layer of moist sand an inch deep; over this place a piece of thick cotton cloth of the same dimensions as the interior of the box; moisten this cloth and, after counting them, scatter the kernels over it, covering them with a piece of moist cotton cloth, the same as that under them. Now place a glass cover over the box, so as to admit light and prevent the rapid evaporation of moisture. Leave a crack, however, at one edge between the glass and the box for the admission of air. Keep the box in a room where the temperature can be maintained at about 85 degrees F. Examine the corn in a day or two and keep the sand and cloth thoroughly moist with water. In from five to eight days all the kernels capable of germination will have sprouted. Count those which have not sprouted. If 200 kernels, for example, were tested and 190 sprouted, the percentage of vitality would be 95. This would mean that out of every 100 kernels planted in the field 95 would grow, assuming the field conditions to be as favorable as those afforded by the germinator.

Corn ought to test at least 97 per cent. under artificial conditions to warrant using it for seed, as in the field it will not often attain such a standard except where the seed-bed has been properly prepared, freedom from insect and other pests is enjoyed and favorable climatic conditions prevail. By testing kernels from a lot of representative ears, the approximate percentage of vitality of the general stock of seed may be ascertained. But where effort is under way to secure the best possible results from small areas, kernels from every seed ear should be tested. Breeding plots in every case ought to be planted with seed whose vitality is known.

Where it is desired to keep a separate record of the germinating power of each ear the three kernels selected from it can be placed in the germinator so that when sprouted no difficulty will be experienced in identifying them. Having this object in view, mark off one of the cloths into checks or blocks about an inch square, using indelible ink, and number them consecutively; on the cloth place the seed to be germinated, as previously described, each set of three kernels being deposited in a separate square. Number each seed ear tested to correspond with the figure or figures in the square occupied by its three kernels. For example, square No. 1 may contain the kernels taken from an ear bearing the same figure of identification. Make the lines forming the squares very distinct and bold, also the figures.

Although as a rule seed corn purchased from reputable growers is tested for vitality before sold, the percentage in some cases being stenciled on the shipping crate, it is best to test it again where the grower desires to breed corn under the most rigid and exact conditions.

Corn selected from the crib should never be used for seed until a representative sample has been artificially germinated. Many growers who ignore this precaution not infrequently use seed that would show less than 90 per cent. vitality. A ragged stand results which they usually ascribe to other than the guilty cause. It is not good practice to use seed testing less than 95 per cent. vitality, 97 per cent. being the commonly recognized standard.

Some farmers, in order to overcome demonstrated deficiency in the germinating power of corn, use a correspondingly larger amount of seed. If the test shows 90 per cent. they plant 10 per cent. more corn than would otherwise be used. Theoretically this might seem a happy way of offsetting the inferiority of the seed, but actual results do not recommend the plan, as when poor seed is used a poor stand and an unsatisfactory crop will result, no matter how much in excess of a normal allowance the amount of seed may have been.

Butt kernels and those at the tip of the ear should not be used for seed, as they are too large or too small to secure, when mixed together and with the central kernels, a uniform distribution by the planter. Seed ears are, therefore, partially shelled off at both ends, the kernels usually being removed from about an inch and a half of the cob at the tip and from the butt as far down the ear as the uneven and ill-shaped kernels extend.

A patent germinator, useful and convenient for germinating all kinds of farm seeds, may be purchased of hardware dealers or from some seedsmen. It is made of copper and will last a lifetime. Success in testing the power of seeds to grow does not depend so much upon the kind of germinator used as upon the maintenance of a uniform temperature of the required degree. A temperature ranging from 50 degrees to 90 degrees F. will produce the desired results, but it ought to be kept at about 85 degrees F. Incubators are sometimes used quite successfully as germinators. How to adapt them to the purpose can probably be figured out by any ingenious farmer.

SOIL FOR CORN.

Soils best adapted to corn are found where the great bulk of the crop is grown. The deep, black, loamy soils of the Mississippi Valley are admirably suited to corn production, though owing to its remarkable root system, corn may be grown under more adverse conditions than any other important agricultural crop. It will succeed in a variety of soils, from light, sandy to the tight clay of the hill regions, but thrives best in a black, well-drained soil rich in organic matter. That it is grown in every state and territory in the Union is proof of its adaptability and indicative of the wide range of soils in which it thrives.

SOIL EROSION.

Corn seldom yields profitably where the soil has washed badly. It is an evident fact that larger areas have been rendered unfit for corn by the washing away of the soil than by persistent cropping. Heavy rains carry away in one day more soil from hilly fields in cultivated crops than two or three men with wagons and teams could restore in several days. To prevent this waste is one of the most vital problems before American farmers at the present time. It can be easily done and without direct cash outlay.

As a rule all hillside soils are very thin, and deficient in organic matter. They, therefore, are made up of very fine particles which do not readily absorb water. Rain, instead of percolating into such soils, tears them loose and carries the dirt off the field. If the soil were deep and porous this could not occur, as the water would be absorbed almost as fast as it fell. Humus, which is decomposed weeds, stalks or other growth which has been plowed under, increases, and in fact is the porosity of soils, augmenting their water-holding capacity and at the same time rendering them more susceptible to the desiccating action of the sun and wind. Before it has time to run into or form little gullies, rain falling on a soil full of this vegetable mold is absorbed, gradually working its way down into the subsoil.

TO PREVENT SOIL FROM WASHING.

In order, therefore, to check the loss of soil by erosion, the land should be seeded to leguminous crops to be plowed under the second year when in luxuriant growth, the plows running at least an inch deeper than the soil has been previously broken. Many hill-farmers prefer common red clover with which to make the initial step in deepening and ameliorating worn hill soils, and practice sowing it broadcast in the spring at the rate of 10 pounds of seed per acre, sowing it in rye or wheat. For fall pasture the rye is of considerable value, especially where there are calves, colts or sheep to graze it. Moreover, it furnishes excellent pasturage in the spring, but stock should not be allowed access to it after the clover seed has germinated. About the time the rye is in bloom it should be cut with a mower; if not too thick it may be allowed to remain on the ground, but if heavy it would better be raked up and taken off the field. It can be used for hay. In either case the clover will generally begin growing rapidly after the sunshine has unobstructed access to the young plants. Ordinarily, the clover should not be pastured the first year, at least not until rather late in the fall, when it may be grazed lightly by young stock. A hay crop may be secured from it the second year and after the second crop (the same year) has attained its full development it should be plowed under.

This will probably be between the first and the 15th of August. The land should then be sown immediately to rape, oats, cow-peas, corn or other quick-growing crop which can be used for soiling or for pasture. Whatever the crop adopted, it should be out of the way about the first week in October for Pennsylvania conditions, when the land should be replowed and again seeded to rye or wheat.

This plan can of course be modified to suit individual peculiarities, and other crops than those mentioned might also be grown to better advantage. Stock farmers can practice this plan more profitably than those who do not raise live stock, as the former can utilize the resultant green feed or pasture to advantage. Several years' treatment will restore almost any type of soil and render it practically immune under intelligent management from further erosion. During the winter and spring when a thin layer of surface soil is alternately freezing and thawing, small loss may occur, but if the ground be covered with matted rye very little dirt will be carried off the field by the water. The rye or wheat stocks will intercept the sluggish, muddy water as it runs in tiny streams down the hill. All hill land should be seeded broadcast so that no rows are left to facilitate the movement of surface water.

Most soils, especially in a prairie country, should be tile-drained. Drainage is of much greater economic importance in American agriculture than is generally believed. The objects of drainage, as the writer recorded them in his note-book when he was a student in an agricultural college, are thus stated: 1. To remove excess water. 2. To lower the ground water table. 3. To guard against the effects of drouth. 4. To prevent washing away of the soil. 5. To deepen the soil. 6. To prevent baking. 7. To promote aeration. 8. To warm the soil. 9. To lengthen the seasons. 10. To prevent frost from upheaving the crops. 11. To prevent souring of land and disease germs from accumulating. It will, therefore, be seen that tile drainage may be of as much benefit to hill land as to low lands.

Summing up the foregoing, corn requires for best results a deep, rich, porous, well-drained soil. If planted in hilly fields it should be drilled crossways of the slope, and shallow, level culture practiced. Rape, clover or cow-peas or other crop should be sown just before the final cultivation, so that the surface between the rows may not be naked and thus liable to wash in event of hard rains. Many types of soil, at present unfit for lucrative crops of corn, can be got in excellent condition for corn by keeping the land busy—by constantly protecting it with a cover of a legume or other forage crop. The more a poor soil is worked and intelligently cropped the sooner it can be rehabilitated. Idleness is opposed to improvement in anything. Soils do not need rest; they need different crops and better tillage.

In several of the corn-belt states ideal soil for corn was made by nature; in many other sections it must be made by man aided by nature. Unpromising corn soils have been made to produce 125 bushels per acre. What has been done can be repeated.

FOOD FOR CORN PLANTS.

Like animals, plants require food. They derive it from the soil and air. Three elements of plant food are the principal ones of more than a dozen which plants utilize. These are nitrogen, phosphorus and potassium. Soil markedly deficient in any of these will not produce a profitable crop.

Nearly all virgin agricultural soils contain all the elements of plant food in suitable amounts for maximum crops. On account of persistent planting to one crop, corn in some states, wheat in others and cotton in the South, many soils are now demonstrably deficient in one or more of the elements named, nitrogen and phosphorus in most cases. Of these the former is the more expensive, its commercial value being usually about 15 cents per pound. Fortunately it can be obtained practically free of cost from a source where the supply is unlimited—from the atmosphere, four-fifths of which by volume is nitrogen.

OBTAINING NITROGEN.

Leguminous crops, such as clover, alfalfa, cow-peas, soy beans and vetch, are collectors of nitrogen. Clover, for example, improves the soil and thus makes the crops better because it adds to the available supply of nitrogen. It is this element which gives to corn that dark, green color and vigorous health which usually mean a good crop. But none of the legumes can take nitrogen from the air without the aid of micro-organisms or bacteria which, when present, form on the roots of the plants nodules or tubercles, varying in size from a pinhead to a green pea. These bacteria in some way, not yet fully understood, take nitrogen from the air, and render it available for use by the plants to which their habitats (tubercles) are attached. Unless tubercles are found on the roots of the plants, neither clover, alfalfa, vetch nor any other legume can be of any appreciable fertilizing benefit to the soil. For this reason, in many instances, artificial inoculation is resorted to in order to insure the presence of the bacteria. This consists in sowing by hand in the field of clover, alfalfa or other legume which has no tubercles on the roots, about 100 pounds per acre of soil secured from an old-established and successful field of the particular legume which it is desired to inoculate. Infected soil may be sown either in the spring or fall. In a year or two one acre will afford sufficient bacteria for infecting the entire farm—and many other farms.

It is an easy and simple matter to find out whether the bacteria are present in one's soil which is supporting a legume. In the first place, the general thrift or lack of thrift of the plants will indicate the fact to the initiated. Green, vigorous, healthy-looking plants are a reasonably reliable evidence of their presence, especially on rather thin soils where such growth is unusual. Yellowish, sickly plants more conclusively demonstrate the absence of bacteria; but to make sure of it three or four plants in different parts of the field should be dug out carefully and their roots examined. If the plants are pulled out the tubercles if present will be broken off in the ground. Consequently it is necessary to remove them carefully and crumble away the dirt from the roots.

A soil may be assumed to lack nitrogen in proper amount for best results in corn production when a gradual diminution in the yield of this or other crops is noted. If it has been cropped with grain for many successive years, the crop being sold off the farm, it is reasonably sure to be deficient in nitrogen. One or more of the other elements may also be deficient, but as nitrogen is removed in large amounts and is probably less abundant in soils than either of the other principal elements, its exhaustion is sooner brought about. Therefore, one of the first steps ordinarily in soil-building is to grow crops that will supply nitrogen.

Corn appropriates plant food generously, a crop making 40 bushels per acre utilizing, according to Schweitzer,* about 83 pounds of nitrogen, 25 pounds of phosphorus and 61 pounds of potassium. It must have adequate food in available form and plenty of moisture in order to produce a remunerative yield of grain.

IMPROVING SOILS FOR CORN.

To improve a soil for corn it is advisable, generally speaking, first to seed the land to alfalfa or clover and see to it that the proper bacteria are present. If neither of these legumes succeeds satisfactorily, a reliable conclusion is that the soil needs lime to correct its acidity, for legumes will not thrive in soils markedly acid. Applications of air-slaked lime at the rate of from 500 to 5,000 pounds per acre, depending on the degree of acidity, and worked into the soil by harrowing in the spring, may be relied on to fit the soil for a legume. About two years in such a crop would result in great chemical and physical improvement of the soil. Succeeding crops, especially of grain, would show the beneficial effects of the added nitrogen, though not a little of the improvement observed would probably be due to larger amounts of phosphorus and potassium made available by the action of the lime and the new physical conditions set up by the leguminous plants. Once the clover, the al-

*Bull. No. 20, Mo. Expt. Station.

falfa, the vetch or the cow-pea bacteria are introduced (there are different kinds of bacteria for different kinds of legumes) they are not likely to be got rid of where their hosts are grown with any degree of regularity. Therefore, when the problem of getting a legume to grow successfully (and that means with the tubercles) is settled, the question of procuring or maintaining an adequate nitrogen supply also is solved.

But corn may also fail to yield paying crops on account of not getting enough phosphorus, though this is not often found to be true. This element may be supplied in the form of bone meal, which is probably more satisfactory than acid phosphate. The latter is importantly cheaper than bone meal, and in the corn-belt is now more extensively used, but it does not show results as quickly as bone meal.. It is sold by some of the packing establishments at the leading live stock marts.

Barnyard manure applied soon after it is made will add considerable nitrogen and phosphorus to the soil, but on thin, clayey soils its chief value is perhaps due to the organic matter which it supplies. There is no better place to use manure than in worn fields intended for corn, though it should be understood, that in improving soils it is necessary to go about the work systematically—to use stable manure, green manure and rotate crops.

SWAMP SOILS AND POTASSIUM.

Peaty or swamp soils, or low-lands lying submerged several months each year, generally do not contain sufficient potassium for profitable crops of corn. The writer has seen in Illinois striking proofs of this fact where an application of potassium to a plot of peaty land made a difference in the yield of corn of 25 bushels per acre, an adjoining plot producing absolutely no grain. Potassium may be bought in the form of potassium chloride (containing about 42 per cent. of the element) at from 5 to 7 cents per pound. About 200 pounds per acre should be used in treating peaty soils, sowing it on the plowed surface and disking it in about 10 days before corn-planting time. From 100 to 200 pounds per acre should be applied each succeeding year for a period of several years. The cost in most instances will be more than offset by the increased yields produced each year.

Nitrogen, phosphorus and potassium are the elements of plant food which most concern the farmer, and on the majority of farms where corn is grown, nitrogen is the one which should be considered first in setting about to make the soil more productive. Commercial nitrogen costs at least 15 cents per pound, but atmospheric nitrogen can be obtained through the agency of legumes (provided they have the proper bacteria), in large amounts for less than one cent per pound.

SEED-BED PREPARATION.

In the growing of a corn crop no factor is of more importance than a well-prepared seed-bed.

Seed planted in cloddy, shallow soil cannot germinate satisfactorily, nor can those plants which do appear make proper growth.

Properly to prepare soil for the reception of corn involves a great deal of work in some cases, though where the soil breaks up well a few harrowings usually will suffice.

Fall-plowed fields should be double-disked in the spring when the soil is in good workable condition, and then worked with a harrow that smooths the surface and crushes the clods.

Spring-plowed fields do not ordinarily require disking except where clover or alfalfa has been turned under, two harrowings being adequate preparation where the soil crumbles nicely in plowing.

In fitting land for corn, the aim should be thoroughly to fine the soil, smooth the surface, mash all clods likely to interfere with planting or early cultivation, and compact the furrow slices.

Where grass, straw, weeds or cornstalks are plowed under in the spring, it is a good practice to roll the field afterwards, so as to establish capillarity as far as possible between the soil of the furrow slices and that immediately underneath them. This intervening layer of organic matter is responsible for the failure of corn plants to secure adequate moisture in periods of light rainfall or drouth. As there is no intimate connection where this stratum exists between the plowed soil and the underlying subsoil, moisture can not rise to the immediate region occupied by the corn roots, and, hence, the crop is cut short. A heavy growth of vegetable or organic matter plowed under just before any crop is planted or sown in such soil almost invariably proves a handicap by decreasing capillary action. A roller can often be used with advantage in the preparation of soil for cereal crops. It is a good implement to have on the farm.

In the opinion of many successful corn-growers, the most satisfactory preparation of land for this crop consists in plowing the soil deeply in the fall at a time when it is in the best condition, disintegrating nicely as the furrow slices are turned, and depending on the sun, water, wind and freezing and thawing to give it a course of chemical and physical treatment during the winter. Except where the land is rolling and thus likely to wash badly before planting time, fall-plowing is preferable to spring-breaking for corn. This seems to be generally admitted after years of discussion of this important question. Sod or clover fields ought always to be plowed in the fall when possible.

As soon as the soil becomes friable in the spring the disc harrow, set so as to cut up the soil quite thoroughly, should be run over the

field both ways and be immediately followed by a pulverizing and smoothing harrow. If clods abound in profusion, a heavily-weighted roller should follow the harrow. Then a harrowing will work up a layer of loose, fine soil resting on a compact, settled foundation, and so be in ideal fix for the planter. If the planter does its work right it ought to put the seed in at a uniform depth and cover it with soil through which the plumules without difficulty can thrust their tender heads.

It is almost impossible to work a late spring-plowed field into the best condition for corn planting, as it often happens that on account of rain and a great deal of plowing to do, some fields are broken when too wet and thus bring legions of large and very slowly dissoluble clods into annoying evidence.

So far as practicable, the grower should provide and maintain the most favorable conditions for the germination of the seed, the growth of the plants and the harvesting and utilization of the crop. Germination is influenced materially by heat, moisture and air; in fact, these are vitally essential. Unless the seed-bed is well prepared the processes of germination will occur slowly, if at all in some cases. The soil for best results must be finely pulverized, mellow, and rich in humus, so that it will absorb heat, admit air freely to the buried seed and keep the capillary moisture movement in progress. Finally, a seed-bed that is in the right fix means stronger growth of the corn and less trouble with weeds.

PLANTING CORN.

Many growers make the mistake of planting corn too early, and perhaps almost as many, through bad management in a number of cases, do not get the seed, especially of late varieties, in the ground early enough for best results.

No two seasons are alike. That corn was planted at a certain time one year is no reason why it should go into the ground on the same day the following year. Planting should be deferred until the soil loses its winter chill and absorbs warmth from the sun; in other words, until danger of frost is past. It does not pay to put the seed in cold, wet soil.

One of the most important advantages of fall-plowing is, that it puts the farmer in control of his spring work, aiding him especially in getting his corn planted without delay. Those who have large areas to plow in the spring for corn usually are late planting the seed. Moreover, where considerable vegetable matter is turned under at this season, corn is likely to be injured more in case drouth ensues than would be the case on the same land plowed in the fall.

Thorough preparation should be made for planting. The ground should be in the best possible condition and the seed well graded, so that a uniform distribution may be effected by the planter. Almost any of the improved two-horse planters will drop the kernels with regular accuracy provided the seed has been previously graded. The way to grade it is to run it through a good fanning mill, which separates the small and light grains from the larger and heavier ones. It pays immensely to put all seed corn through a fanning mill. By using graded seed a uniform number of kernels will be discharged by the planter and an even stand result.

There are many satisfactory two-horse planters on the market.

Before driving the planter into the field the machine should be tested fully as to its regularity in dropping the desired number of grains. This may be done by hand tripping it, the planter being stationed on a clean, hard, grassless bit of ground or upon a floor. Planters are provided with a series of plates made to drop different numbers of kernels of a given size. They also are fitted with drilling devices.

AMOUNT OF SEED TO USE.

In the corn-belt the generality of growers aim to get about three grains in the hill, the rows being three feet six inches apart both ways. In a great many cases, however, especially on rich clover land or sod soil, thicker planting is done, and drilling at the rate of a kernel every eight or ten inches is not infrequently practiced. Experiments indicate that there is no appreciable difference between the average yields of drilled corn and that planted in checks, where the same aggregate amount of seed has been used. Drilled corn cannot of course be cross-cultivated except when young, when the harrow or weeder may be used, and in old cultivated fields it would be difficult to keep free from weeds. But very hilly fields ought always to be drilled, as if checked soil erosion is greatly facilitated. In such fields the rows should run at right angles to the slope of the hill. Checked corn is more easily kept clean, being capable of cultivation both ways with all kinds of standard cultural implements. As between drilling and planting in checks, there is no noteworthy difference except that the latter facilitates cultivation. Experience in growing corn, planted both ways, and extensive observations confirm the general belief that the method of distributing the seed does not influence the yield except in unusual instances. It is the total number of stalks per acre which determines the outcome.

Upon the use to which the crop is to be put depends the distribution of the seed. Corn for forage, soiling purposes or the silo may be planted thicker than that intended for high-class seed or the production of large, well-developed ears. As already mentioned, most

growers plant from three to four kernels in a hill, though many of them, failing to grade the seed, plant from three to eight grains in a hill, making a general average of more than enough. A plate made to drop three kernels at each tripping cannot be expected to do so unerringly when kernels of all sizes and shapes are used for seed.

Corn should be planted from two to three inches deep. In deep-plowed, well-prepared, mellow soil there is danger of getting some of the seed, especially the smaller and weaker specimens, too far down in certain parts of the field, unless the operator manipulates the planter properly. Where the seed-bed has been thoroughly worked and fined, uniformity of depth of planting is assured.

It takes a little more than a bushel of 56 pounds of seed to plant 8 acres where the hills are three feet six inches apart both ways. With a good team, long rows and a square field from 10 to 15 acres per day may be planted with a check-rower.

MAKING STRAIGHT ROWS.

Unless he has had experience in operating a planter it is difficult, almost impossible, for any one to get the corn straight both ways in a triangular or odd-shaped field. A first-class job with a check-rower consists in planting the corn absolutely straight both ways. This requires an energetic team, well-matched as to disposition and rate of speed in walking, a driver who understands how to set the cable and takes pride in his work. Although it is easy to make straight rows, indifferent hired men often make them crooked both ways, especially the check rows. To make them straight in either direction it is necessary to start right and keep right. The fly-end of the reeled cable should be fastened to the iron stake and the latter anchored in the corner of the field where the work is to be started; then the machine carrying the spool of cable is driven to the other side or end of the field, unreeling the chain a few feet to the right of where the outside parallel row will be planted. After laying the chain across the field it should be stretched reasonably taut and fastened at the other end, when it is connected with the planter and the work begins. As near as possible the chain should be stretched to the same tension every time it is set. Where the rows lengthen or shorten, as the work progresses, it is best to set up stakes at the irregular end, setting one every 40 or 50 feet at a point touched by a button on the wire, the series of stakes representing a cross row. By this means the operator can keep all the cross rows straight, setting his chain so that a certain identifiable button is constantly in direct line with the row of stakes.

In case of violent surface irregularities, such as ridges or deep depressions, it is almost impossible to make the cross rows perfectly straight, be the operator ever so careful.

Some of the two-horse planters can be used without the cables, being fitted with hand-dropping attachments. Where this arrangement is used it is of course necessary to have the field marked off or checked crossways, where the corn is to be planted in hills.

Small fields can be planted with hand planters—commonly called "jobbers." These devices are still extensively used in stumpy or stony fields where a horse-planter could not be operated successfully. They do satisfactory work and their use insures proper covering of all seed, as the operator with his foot can help in this direction. Moreover, there is no chance of making crooked rows when the "jobbers" are used, unless the rows are "laid off" crooked. With a three-row sled marker it is a simple matter to lay off a field straight both ways, and the work can be performed at the rate of 30 to 40 acres per day. It puts a field in readiness for hand planting. Hand planting is advisable wherever the acreage is too small to warrant the purchase of a horse-planter.

The aim should be so to distribute the seed that none of the resulting plants will be crowded. Small-growing varieties can of course be planted thicker than those producing large stems and large ears. There ought to be as many plants in a field as can be cultivated conveniently, yet they should not crowd each other, unless the object be stover, in which case very thick planting is in order. Ample room must be allowed, however, where big ears are desired. Where drilling is done the rows should run north and south, so as to admit sunshine as freely as possible between the rows.

CULTIVATION.

That system of corn cultivation is most effective and economical which removes weeds, conserves moisture and areates the soil.

To prevent the evaporation of soil water, is undoubtedly the most important office of cultivation. After rains, if the soil is not stirred it bakes, cracks form and moisture escapes rapidly. If the soil is stirred as soon after rains as its condition permits the surface crust cannot form. Capillarity is destroyed by this operation, and instead of the moisture evaporating through the soil tubes it is retained for use by the thirsty plants. The absence of weeds, therefore, is no excuse for the abandonment of cultivation.

To prevent the formation of a hard, baked or crusted surface, which condition facilitates the escape of soil water, is the vital function of tillage.

DEEP VERSUS SHALLOW CULTIVATION.

Deep and shallow culture experiments, and the experience of all observant corn-growers who have given the subject intelligent at-

tention, indicate that for practically all soils adapted to corn, surface cultivation best serves the purposes of tillage. Differences of from ten to twenty-five bushels per acre in favor of shallow culture as against deep plowing of corn are not uncommon in the corn-belt where the two systems of cultivation have been thoroughly tested and compared under average conditions.

Surface culture, which means that the implement used shall not disturb the soil to a greater depth (preferably less) than four inches below the surface, stirs the soil without pruning or injuring the foraging or feeding roots of the plants and, by forming a mulch on the surface, reduces very materially the evaporation of moisture.

DEEP CULTURE INJURES THE ROOTS.

While deep culture does not accelerate the evaporation of moisture, experiments showing that if practiced with the same regularity as shallow tillage, it conserves as much soil water as the latter method, in nearly all cases the yields of corn grain from shallow-tilled fields have been appreciably in excess of those obtained under identical soil and climatic conditions from deep-plowed fields. The difference generally is attributed to the fact that deep culture injures the roots of the plants. After the corn plants have attained a height of eighteen inches or two feet the fields from near the first six or eight inches of the surface soil contains a network of roots. These roots are so numerous that nearly every square inch of soil taken from a field in which corn plants are ten weeks old would show, if examined, several tiny rootlets passing through it. All these roots are of vital service to the plants. They are the feeders supplying plant food and imbibing water for the building up of plant tissue. Most of these feeding rootlets grow comparatively near the surface, depending, however, upon the character of the soil. Investigations have shown that the fourth inch of soil contains more corn roots than the three inches above it or the four inches below it. For this reason any implement which works the earth in their territory interferes with the nourishment of the plants. It prunes the roots and thus decreases the capacity of the plants to draw food and water from the soil. Fig 7 shows the effect of root pruning on the plants composing the groups numbered 2 and 3. No. 1 represents plants which were not root-pruned, which is equivalent to saying that shallow cultivation was practiced. The yields made by the fields which the three groups of plants respectively represent were 62 bushels per acre for No. 1, 45 bushels for No. 2, which was pruned or cultivated four inches, and 30 bushels for No. 3, which was pruned

Fig. 7. Groups of stalks or "hills" showing the effect of root-pruning or deep cultivation.

or cultivated six inches deep. The more roots a plant has the greater its power to nourish itself. Any system of cultivation, therefore, which cuts off roots is to be avoided.

WHEN TO BEGIN CULTIVATION.

Cultivation in many instances should begin before the corn germinates. A harrowing at this time, or better, one stroke of the weeder, will render subsequent cultural work easy by exterminating weeds that have just begun to grow. In the absence of a weeder, a situation almost impossible to imagine on any Pennsylvania farm of considerable acreage and diversified interests, an ordinary tooth harrow may be used, the teeth being set to slant backwards at an angle which will insure against dragging out any of the planted seed. It is not advisable to use this type of harrow, nor is the weeder successful, where cornstalks, high corn stubble or other kinds of rubbish composed of large weeds have been plowed under the same or preceding year, as the teeth of the implement will engage the partially covered stalks or weeds and in dislodging them drag out a large percentage of sprouted kernels which the hot sun will kill.

THE USE OF A WEEDER.

On clover or wheat land, or in any field free from rubbish, a weeder may be put to work as soon as the corn plants make their appearance. For effective, thorough work at this stage, no cultural implement has proved of greater value to the corn-grower than the modern type of weeder. It is a labor-saver and a corn-maker. Its intelligent, timely use leaves very little for the cultivator to do in "laying by" the corn. But this valuable tool has been incorrectly named, and so in some cases has been called on to perform work for which it was not designed. Instead of a weeder, which conveys the idea of weed destruction, it is a weed preventer. Its most proper function is to prevent young weeds, just emerging from seeds near the surface, from becoming established competitors of the corn plants and at the same time lightly to stir the top soil. Its teeth do not run deep enough to injure the corn roots, and unless there is much trash or rubbish an inch or two beneath the surface very few corn plants will suffer from the operation of this machine.

A weeder may be used until the corn is more than knee-high, though it would better be dispensed with in most cases before the plants have reached this stage of growth, as injury is likely to result from the bruising of the plants, and thus lessen the yield.

Unless wet weather defers tillage until weeds have gained quite a stubborn foothold in the cornfield, about all the cultivation corn requires during the first three or four weeks of its growth can be given with the weeder. So long as the conditions favor, this implement should be used liberally, the aim being to keep the young weeds in check and a dust mulch on the surface.

CONSERVATION OF MOISTURE.

Corn plants during the months of July and August draw heavily upon the moisture of the soil, and as drouth frequently prevails over large areas of the corn-belt at this season of the year it behooves corn-farmers to husband the water supply in the soil. With but few exceptions, there is ample moisture present in the tillable ground at corn-planting time to grow, without aid from subsequent precipitation, a maximum crop if it were possible to utilize it as needed by the plants. That is to say, if the grower could retain in the soil all the moisture contained in it at planting time he would be independent of rain during the remainder of the vernal season.

Moisture escapes from the earth through capillaries or tube-like openings, being drawn by the heat of the sun. An ignited lamp wick draws oil out of the bowl of the lamp on the same principle. The only way to reduce the loss of moisture through capillary attraction is by keeping the soil capillaries broken up. When there is

a crust on the surface these capillaries are integral, and the evaporation of moisture on warm, sunny days takes place with marvelous rapidity. So long as the top soil is fine and loose the liberation of moisture through capillary attraction occurs very slowly.

WATER NEEDED BY PLANTS.

Frequent cultivation of corn, especially during periods of crust-forming rains, is required, not so much by the presence of weeds as by the necessity of conserving moisture for use by the inveterate drinkers which utilize about 300 pounds of water in making one pound of dry matter.

Dry matter is what remains of a plant or other organic substance after its water or moisture-content has been driven off by heat. If a shock of corn fodder were thoroughly dried, absolutely freed of its moisture by heat or otherwise, and its weight ascertained at, say, ten pounds, for convenience, it is easily determined that in forming that amount of dry matter the plants from which it was divided utilized 3,000 pounds, or more than 375 gallons, of water.

Without an adequate supply of capillary water plants cannot make the best growth of which they are capable; consequently it behooves the farmer to practice cultural methods that will husband soil moisture. But if the roots of the plants have been severely pruned by deep plowing it would be impossible to grow a maximum crop even where the soil and moisture conditions were perfect. Corn plants require a large amount of water and in order to use it they must have an abundance of roots. The crux of the matter, therefore, is to cultivate corn often and shallow.

THE SURFACE CULTIVATOR.

As soon as the weeder is dispensed with or its use is precluded by the size of the plants, surface cultivators (see Fig. 8), provided with knives which skim the surface, should be used. These implements cannot be worked with satisfaction on certain types of heavy, clayey soils (neither can the weeder), as the knives of the cultivator drag over weeds without cutting them, and in the case of the weeder the teeth do not loosen the compact surface.

The best cultural implements for corn do their best work in deep loose soils free from rubbish and smooth of surface. For this reason the grower who would produce large yields should select his corn land with proper regard for these considerations.

Where soil conditions and the growth of weeds render ineffective the operation of the surface cultivator, it is of course necessary to resort to the implements with shovels, though it is certain that in using them the roots of the plants will suffer. But as between

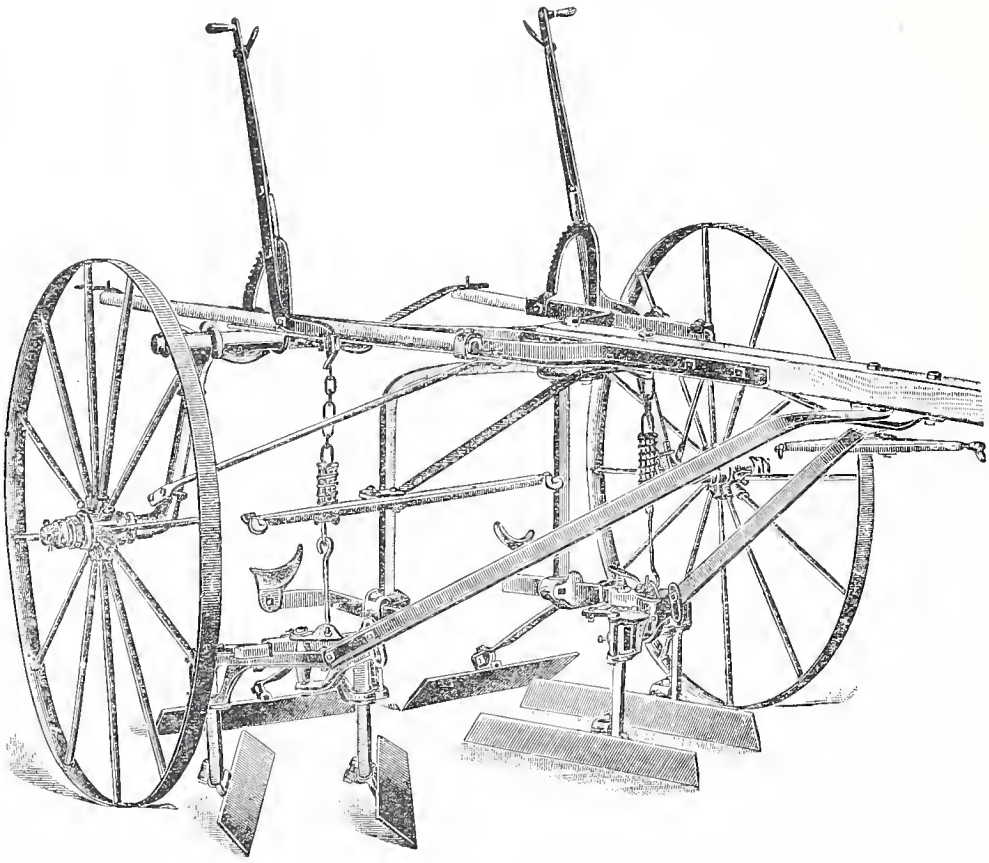

Fig. 8. A good type of surface cultivator, which does not root-prune the plants.

weeds and injured roots it is perhaps advisable to permit the latter condition, as where weed growth is rank both food and water are robbed from the corn plants. This reduces the yield. Where it seems necessary to use the shovel cultivator, which is too commonly employed in some sections of the corn-belt, care should be taken to reduce to the minimum the injury to roots. The shovels or discs should be set to run as shallow as possible in removing the established weeds.

"LAYING BY" CORN.

In "laying by" corn, it is best for the future use of the field to leave the surface smooth. It is particularly important in rolling districts to avoid ridging at the final cultivation, as where this pernicious system is followed in hilly land, washing or soil erosion is disastrous. By using the tillage implements recommended it is possible to keep the surface smooth from start to finish.

The old notion that the brace roots of corn plants which make their appearance in finger-like fashion at the bases of tasseled plants should be covered with soil, dirt being thrown to the corn rows with this object in view, is false. Ridging corn, especially when it is

"making," as we say in June and July, is a harmful practice. It increases the area exposed to the sun and thus augments the evaporation of moisture, and, as in throwing enough dirt to form ridges it is necessary to run the shovels quite deep, much damage is done the roots.

Where fields are given final cultivation with shovel cultivators and the rows ridged to a height of six or eight inches, the surface is

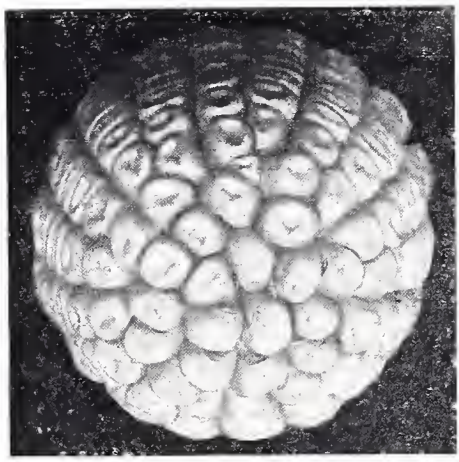

Fig. 11. A perfectly-filled tip, a purely fancy point of unimportant practical value, but eagerly sought by professional exhibitors of corn.

rough, especially in winter, to drive any kind of a vehicle or implement over, and is hardly suitable for meadow or pasture.

Smooth, shallow and frequent should be the culture of corn from the sprouting to the "shooting" period.

The better the soil the better the cultivation should be, provided maximum yields are desired.

Remember that corn plants are living things that have the power of absorbing food from the soil and air, and that this vital power is weakened by any implement which prunes their roots. No factor in the production of corn is more important than cultivation.

REPLANTING CORN.

Unless the crop is intended for forage or soiling, it seldom pays to replant corn, especially where the percentage of vacant hills is small. Replant-corn is subjected to severe competition in that fierce struggle for food and moisture which is constantly in progress between plants growing near each other.

Where 20 or 30 per cent. of the seed fails to germinate, replanting should of course be practiced, though it should be done promptly, so that the late plants may "catch up" as rapidly as possible with their older neighbors. At best, replant-corn usually produces only

nubbins, though the forage is generally of excellent quality, the stalks being small and the leaves fine.

Replanting is most economically done with a hand planter as soon as it may safely be assumed that all kernels which have not sprouted are incapable of germination. When the weather and soil conditions are favorable, good seed corn should issue plants in from five to eight days. Kernels that have not germinated at the end of 10 days in fields where most of the hills are in evidence may be regarded as lifeless. Where germination is slow under favorable conditions, it is highly probable that the seed is weak in vitality. Sound, viable seed should show sprouts within eight days. If good seed is used and the seed-bed properly prepared replanting will not often be necessary. In case half the seed fails to germinate it is better to plant the entire field again than attempt to replant only the unoccupied checks. Replanting may be done with an earlier variety than that used in planting the field at the outset.

DETASSELING CORN.

Several experiments have been conducted to ascertain the alleged advantages of detasseling corn, those who advanced the idea contending that by cutting off the tops of alternate rows of growing plants a greater supply of nutriment would thereby be transferred to the ear or grain instead of the tassel, which, as is well-known, draws heavily upon the plant nutrients. This is based on the more rational but hardly analogous theory, that by thinning young fruit on an apple tree, for example, the remaining apples will receive an increased amount of nutriment and thus grow to greater size and perfection.

Results from beheading corn plants in the interest of larger and better ears have not shown a sufficient increase in yield to warrant the operation. Plant surgery of this heroic type is unprofitable. Nature cannot be stimulated to abnormal activity in man's behalf by his efforts to direct her energies according to his fancies—at least not in the case of corn. But detasseling to prohibit inbreeding or self-pollination to bring about cross-pollination (which is highly desirable), pays. In Illinois it has markedly increased the yield of corn which continued for a period of several years, as at the Experiment Station. Inbreeding in corn is as objectionable as in animal breeding.

By inbreeding or self-pollination is meant the transfer of pollen from the male flower (tassel) of a given plant to the female flower (silk) of the same plant.* Detasseling also prevents close-pollination, by which is meant the transfer of pollen from the male flower of one plant to the female flower of another plant in the same row, both of which grew from kernels from the same seed ear.

*Circular 74, Ill. Expt. Sta.

To show how detasseling increases the yield it is necessary to explain that in Illinois, scientific corn breeders use what is called the row system in breeding plots. This is a somewhat complicated scheme, and instead of presenting it in detail it will suffice to elucidate the general principles involved.

Each of say 50 ears is planted in one row (the rows are parallel and each one is long enough to require practically all the seed in a given ear to plant it); before the pollen matures on the resulting plants alternate rows are detasseled. This compels cross-pollination of the detasseled plants, from which seed for the next year is selected. It makes sires and dams in corn breeding, the detasseled stalks furnishing dams and the tasseled stalks the sires. The best types of ears are selected from the detasseled rows. Some breeders are so particular that they consider in selecting these seed ears the height, size and general characteristics of the stalk, the height of the ear from the ground, the length and size of the ear shank and the number of ears per stalk. Other breeders are content to procure seed ears from the detasseled rows which produce the largest number of first-class ears that will shell out the most corn.

If, for example, four seed ears are selected from each of the 25 detasseled rows, two of them are used the next year for dam seed and two for sire seed, the dam rows being detasseled at the proper time. This process necessitates careful record-keeping and labeling. Each ear is numbered and the row in which its kernels are planted is labeled correspondingly. In this way performance records of individual ears can be kept, and actual pedigrees of dams established, as already has been done by breeders in Illinois. Inbreeding is entirely eliminated and the seed crop each year represents the mating of pollen and ovules—male and female—from absolutely unrelated, unakin ancestry.

Corn bred in this scientific way, as experiment show, acquires greater hardiness, prolificacy and constitutional vigor, to use terms employed in animal husbandry literature. Greater virility is secured in the seed, and "blood lines" are combined and blended in a way which makes for the highest vitality in the seed. Increases in yields of from 10 to 15 bushels per acre have been effected in Illinois by practicing this method. Its practical value has, therefore, been well demonstrated.

BARREN STALKS.

Where effort is under way to breed corn, all barren stalks should be removed before the pollen matures, as, according to Shamel,* if this pollen should fertilize the silks or female organs of neighboring plants the tendency to barrenness would thus be transmitted to

*"The Book of Corn," p. 64.

future seed. All breeding plots should, therefore, be examined diligently two or three times at intervals of three or four days before the tassels begin to liberate their millions of pollen grains, and all stalks detasseled which have no signs of ears on them.

Many stalks do not produce ears because of the work of insects, either above or below the surface, and smut undoubtedly is responsible for many cases of barrenness. Still other causes may be assigned, but whatever the cause the corn breeder, according to the authority quoted, should not permit the unfruitful plants to breed the defect into the seed corn. Either the entire barren plant should be removed or its tassel pulled out by hand, being careful to include no other par of the plant with it. This work can be done speedily by a man who knows the corn plant. At a glance he can tell whether a "shoot" is coming through, and whenever the glistening silk is seen further examination is unnecessary.

The foregoing is the doctrine current a few years ago, and as a result many corn breeders practiced detasseling quite faithfully. At present, scientific doubt exists as to the transmissibility of barrenness in corn plants, Hunt,† among others, holding that "barrenness does not seem to be a variety characteristic" and "if it were an hereditary characteristic the fact that the stalks were barren would tend to eliminate them." If barrenness is not hereditary it cannot be transmitted to future seed. Detasseling, therefore, is of doubtful value. although the Illinois Experiment Station in a circular just issued says that "plants * * * which appear imperfect, dwarfed, immature, barren, or otherwise undesirable, should not be allowed to mature pollen." These counter views are given merely to show that theories in reference to the methods of effecting improvement in corn are changing as the years unfold.

COMMON INSECT ENEMIES AND DISEASES.

According to a leading entomologist, there are about 225 species of insects which, in this country, attack different parts of the corn plant. Only a few of these, however, need here be considered, as most of them are of minor importance.

In the corn-belt probably the most serious insect foes of the corn plant are those which infest the planted seed and the roots. The wire-worm belongs to this class; so does the corn root louse. Root blight, a fungous disease, also works on the roots.

Corn, failing to make satisfactory growth, usually is the victim of either a disease or insect pest. Plants that wither or turn yellowish in most cases owe their abnormal condition to the work of wire-worms or the well-known white grub. There is no mistak-

†Thomas F. Hunt: "The Cereals of America," p. 151.

ing the work of cut-worms, the tender young plants, clipped off at the surface, leaving no doubt as to the identity of the marauder.

Greater injury can be done to the corn plant by underground enemies than those which confine their operations to the aerial part of the plant, yet there are insects and fungous diseases which form a serious menace in certain seasons and communities to the above-ground plant.

Where small fields or plots of corn are grown specially for seed, many remedial measures and methods of prevention may be resorted to which would not be practicable where very extensive areas were involved.

In combating insects and diseases an ounce of prevention is worth pounds of cure. For this reason the corn-grower should rotate his crops and do his plowing with a view of routing or circumscribing those pests which his experience has shown do most injury to his crops. Fields planted successively to corn are almost sure to be invaded by insects which might be avoided through the systematic rotation of crops.

The Wire-Worm.—The wire-worm is a slick, hard-shielded, yellowish-brown, six-legged round worm with a glistening covering. Planted seed corn affords it a favorite diet, but it also attacks the fine roots and bores holes through the stalks below the surface. Its favorite habitat is sod or grass land, and corn planted in sod fields plowed a year or two previously rarely escape its ravages. Several methods have been adopted in coping with this worm, but none of them has proved adequately effective. At the present time it is generally believed that the best plan is crop rotation. Instead of planting new sod land to corn, sow it to wheat or plant to some other crop and follow with clover or alfalfa for two years; then plant to corn. This is a rotation that can of course be variously modified to suit individual conditions. During this process land previously infested with wire-worms will be almost entirely cleared of them.

Seed Corn Maggots.—Planted seed corn also is injured by seed corn maggots, usually after it sprouts. Like wire-worms they are inhabitants of pastures or meadows, and corn planted in these sod soils is quite likely to be injured by these small white worms, which are about a quarter of an inch long. Although there is a successful but very complex method of protecting corn against the seed corn maggot, practical growers believe a rotation similar to the one recommended in the case of wire-worms to be preferable.

The White Grub.—Every corn-grower of experience has seen the white grub. It is an ubiquitous insect, and in some seasons is the cause of large loss to corn-growers. It works on the roots of the plants, the main root being its lethal choice. Grubs are commonest in pasture lands planted to corn the same year of, or two or

three years following, its breaking. They hatch from eggs deposited in ground covered with grass. Therefore, if corn follows pasture or meadow, grubs may be expected. As hogs are fond of these juicy, pulpy worms their eradication may be aided by allowing the herd during early autumn to root in the meadows or pastures before and after breaking the sod for corn. It is considered advisable, however, to devote the land to some other crop for a year or so before planting it to corn. Starvation is one of the best eradicators of insects. Breaking up their homes and constantly changing their environment will eventually put an end to practically all the common corn insects.

Corn Root Worms.—A regular change of crops affords sufficient protection of corn against the two common species of corn root worms.

Cut-Worms.—To avoid cut-worms, many corn-growers have found that fields should be sown to winter wheat two years in succession before devoting them to corn. If corn should follow spring-plowed clover or alfalfa, cut-worms would be almost sure to injure it seriously. Turning under either of these legumes just before planting to corn buries the worms, which subsist on the green vegetation plowed under with them until the corn plants begin to emerge. Then the worms work their way to the surface and find a new source of food. Cut-worms can be killed by feeding them a poison mash, which they seem to relish. This mash is composed of 25 pounds of wheat bran, a quart of molasses, a pound of unadulterated fresh Paris green and enough water to give the materials the desired consistency, the poison and bran being thoroughly mixed before adding the molasses and water. The molasses should be stirred in a half-gallon of warm water and then added to the bran and poison, with which it should be incorporated by vigorous agitation. A teaspoonful of the mash deposited near each hill of corn will have the desired result. Poultry should be excluded from treated fields.

Cornstalk Borers.—Cornstalk borers, of which there are several species, need not be feared where the land regularly is planted to a different crop. These worms bore into the stalks and as fall approaches work down into the roots, where they spend the winter.

The Corn Worm.—In its variety of names the corn worm excels all other species of insects. In the South it is commonly known as the boll worm. It has many names because it is found in almost all parts of the country on an infinite variety of plants. Corn worms are more than an inch long and of several different colors. Eggs from which they hatch are laid on the young corn blades and the young insects as soon as hatched begin at once to feed on these parts of the plant. Others are hatched from eggs in the silk of the

"shooting" ears and live on these tender threads until they begin to dry; then they attack the milky kernels, and forage promiscuously under the husks of the ear until it is mature. At this juncture the full-grown worms descend to the ground and assume a new form, while the undeveloped specimens die and decompose in their concealed quarters, rendering the corn unsuitable for many purposes. Early fall plowing of land to be planted to corn the following spring is recommended where corn worms are to be fought.

Army Worms.—Army worms, so called because they migrate together in thousands, are not so troublesome as they used to be, although in some sections they still are to be reckoned with as a serious pest. Perhaps the old way of combating them is the best. It consists in plowing a ditch around or on one side of the threatened field, making the furrow as deep as the plow can be drawn, and throwing the dirt toward the corn, so that the worms cannot climb out of the excavation. By dragging a smooth, heavy log a foot or more in diameter in the ditch two or three times, most of the clumsy worms that have tumbled into it can be killed.

Chinch Bugs.—Chinch bugs are often very destructive of corn, and in the aggregate cause much loss. Where wheat and corn occupy adjacent fields chinch bugs travel, almost invariably by foot, from the wheat to the corn as soon as the wheat is cut. To prevent their invasion of the corn, just before the wheat is cut run a deep furrow around the field which it is desired to protect, then drag a heavy log in it until the sides and bottom are coated with fine dust. Bugs in trying to cross this furrow will fall into it and being unable to secure a footing in the dust cannot crawl out. By dragging the ditch again with the log the captives may be despatched.

The Corn Root Aphis.—In recent years the corn root aphis has come into prominence because of its destructive work in some parts of the corn-belt. It is a minute, soft, bluish-green, six-legged insect, unually wingless, that sucks its food through a hair-like beak with which it punctures plants. The effect of its sucking cannot be detected by any outward evidence, but the plant upon which it is feeding perishes gradually or atrophies. Its presence may be suspicioned where the leaves begin to redden and where the plants do not grow as vigorously as conditions seem to warrant. No practical remedial measures have as yet been devised for the eradication of the corn root aphis, but the changing of crops and the use of the best soil for corn so as to produce a rapid, luxuriant growth may be depended on to reduce injury by this insect to the minimum.

Grain Weevils.—Stored or cribbed corn is often badly damaged by grain weevils which perpetuate themselves in either stored corn or wheat year after year. Eggs are laid in the field, crib, granary or

warehouse by a small moth, and in a week the grain weevils emerge and begin to bore into the grain, eating the inside of the kernels. This destroys them both for seed and food. To exterminate these pests the most effective method is to make the crib or granary as near air-tight as possible, and evaporate in it for 24 to 36 hours bisulphide of carbon, using from a pound to 18 ounces of the bisulphide to the ton of grain. Where large volumes of the fumes can escape through cracks, larger quantities of bisulphide should be used for a longer period, though care should be taken not to continue the treatment more than a day and a half where its full effects are secured, as the vitality of the grain may suffer injury.

Fungous Diseases.—Of the fungous diseases of corn, smut is by far the most important. It is to be found throughout the corn-growing districts of America. Millions of dollars annually are lost by farmers on account of this parasitic disease. Corn smut cannot be mistaken for any other disease once it is seen. A mold-like, lumpy growth is produced, appearing on the stalk, leaf or husk. A light lead-colored covering is formed, which, when the spores are mature or fully developed, bursts, the liberated germs, which are seen in the form of a black-yellowish dust, being disseminated by the wind. This material is carried great distances and wherever it lodges smut spores may be said to exist awaiting the following year's corn crop. The spores live over winter and do not lose their virility when fed through animals back to the land. Smut usually affects the ears, arresting their development and practically ruining them. Happily, this disease does not spread over the entire plant; it merely injures the portion where it breaks out. It develops inside the plant tissue and breaks out like a sore on the surface. It lives on the corn plant. Ears produce more smut and are more commonly attacked because of the greater amount of nutriment which the plant furnishes to that vital part. Smut causes a decreased yield even where it does not affect the ears, as it robs the latter of food. Farm stock eat corn smut without suffering ill effects. Cattle even relish it. Chemically it is rich in protein and carbohydrates. But corn smut is not to be endorsed as a stock food. Unfortunately this disease is difficult to stamp out. Only one course is open, and it may involve a vast amount of work; go through the field two or three times, beginning about the last of June, before the smut balls burst, and remove all fungous growths found on the plants, place them in a bucket and burn them. It may be necessary to go over the entire field five or six times.

HARVESTING CORN.

In the prairie states where corn is widely grown, harvesting often continues until late in January, the common practice being to snap or husk the ears from the standing stalks. Five rows can be harvested at each "through," the wagon being driven astride the middle row, two men doing the husking or snapping. As soon as the crop is harvested, stock is allowed access to the field. In the spring the stalks are dragged down, raked into windrows, and burned. This wasteful practice is quite general in the corn-belt. Harvesting the ears is not harvesting the corn crop; it is merely harvesting about two-thirds of it.

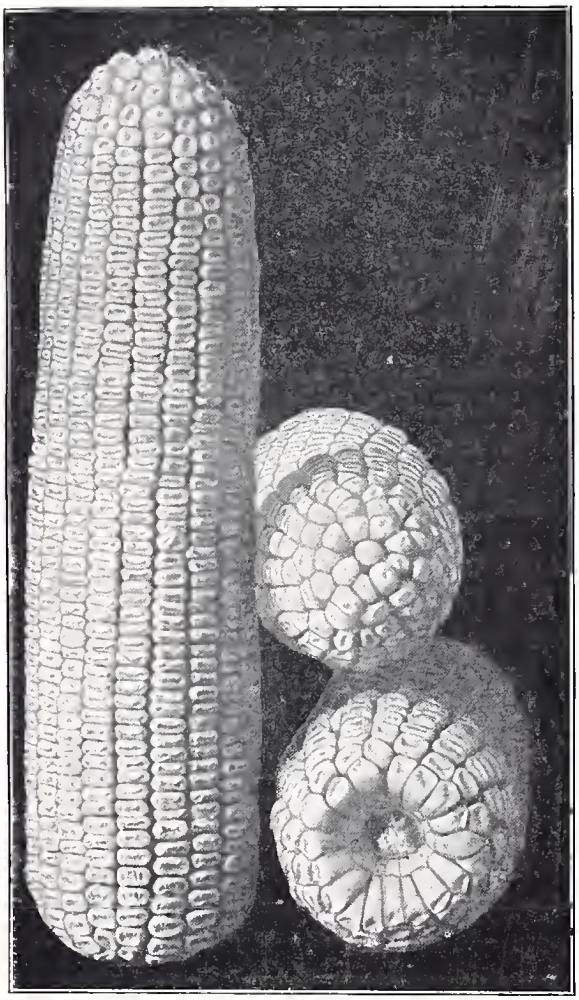

Fig. 12. An excellent type of Reid's Yellow Dent ear, with examples of a well-filled tip and score-card butt.

Where live stock is maintained nearly all the corn grown can be cut for fodder. For cutting, the new improved corn binder discounts the corn knife. Except where many stalks are down the corn binder does its work admirably. It may be profitably used wherever the area warrants. When corn is cut for shocking, about 256 hills are put into a shock, assuming that it was planted three feet six inches apart each way. Smaller shocks are made, however, in many parts of the country.

To build a substantial shock that will stand up well is an art. A good plan where the common corn knife is used is to set up the fodder evenly around a skeleton or frame work composed of the stalks growing in four hills which form a 42-inch square. Where the corn has been blown down and is crooked it is impossible to build satisfactory shocks. As soon as the fodder cures well, two men equipped with a strong rope about 30 feet long with a metal

ring in one end of it, and a ball of binding twine bind up the shocks tightly. One of the men places the rope round the shock and draws it taut while the other ties a piece of twine round it. Shocks of the usual size put up in this manner stand up well and are only slightly damaged by the elements. Of course the corn binder cannot be used in making shocks as described. When husked the stover should be put up in the same form of shock unless it is to be immediately hauled off the field. Stock relish clean, bright stover and if corn is shocked well and the shocks tied as described only a small percentage of the feeding value of the plant will be lost.

The sin of burning cornstalks ought to cease. It will when Americans are compelled to practice intensive farming. All the beneficent corn plant ought to be converted into meat, milk or energy. In this way its fertilizing value also is best realized.

THE SELECTION OF SEED CORN.

Most of the seed corn used on the average farm is selected in the spring from the crib. This is a bad practice. Seed should be selected in the field at harvesting time. Some breeders are particular about the size and general vigor of the stalks from which seed ears are picked, but for practical purposes it is perhaps sufficient that the ears themselves should be satisfactory. Most practical growers do not consider the stalk; they are seekers for the best ears. It has been argued that seed ears grown so far from the ground that the husker has to jump up after them will transmit this undesirable characteristic to the future crop, but there is no evidence to support this theory. Consequently if a desirable ear is found above the reach of a man of average height it ought not to be discarded as seed, until there is proof that the theory is correct.

Select the seed ears during the regular work of harvesting the crop, throwing them into a large box attached to the rear of the wagon-bed. These ears can then be placed in a separate crib or section of the regular crib, and another selection made soon afterwards, the ears thus picked out being ready for storage. In this manner the seed is examined sufficiently to give a good idea of its general character.

If possible, the same man should select the seed ears in the field each year. He of course must have the ideal ear in mind and make his selections annually in accordance with it.

Ears 10 to 11 inches long, 7 to 8 inches in circumference and of good shape should be selected. The second examination of these ears should be more searching than the first. This is the time to make a careful study of types and characteristics. It is the work which breeds familiarity with corn.

Remember that the time to select seed is in the field when the crop is matured. It is an easy job if done along with the regular husking.

STORING SEED CORN.

It has been amply demonstrated that the vitality or germinating power of seed corn depends to a great extent upon the manner in which it is kept from the time it is harvested in the fall until planting time in the spring. When harvested, about 30 per cent. of the total weight of corn is water. During the winter this water or moisture is evaporated. If the ears are thrown into a crib or bin the moisture cannot escape readily and in many cases may cause injury to the seed.

All seed ears should be husked in the field, and, after being as-

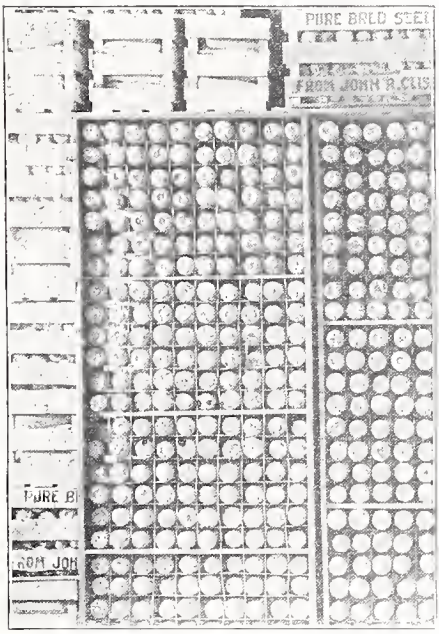

Fig. 9.

Fig. 10.

Fig. 9. Seed corn storage pigeon-holes which are made of wires stretched in a frame.

Fig. 10. Another way of storing seed ears. This storage device is made of slats. Both methods illustrated provide for the free circulation of air around the ears.

sorted or inspected a second time, placed in racks or upon shelves, provided in a dry, well-ventilated room. Figs. 9 and 10 show excellent methods of storing seed ears. Placed in wire racks or on shelves made of small slats, and in a dry well-ventilated room, the corn will dry out rapidly and thoroughly and in this condition will go through the severest winter without suffering impairment of vitality. So long as corn is dry it is safe from injury by climatic conditions.

Where large quantities of seed are selected, special seed corn storage houses are constructed on some of the big corn farms of the West. These buildings are usually equipped so that the ears can be dried by artificial heat. The process is called fire-drying. Professional exhibitors of corn also make use of this process in order to make their samples weigh out as much as possible.

In the case of the farmer who wants to save enough seed for 30 to 60 acres of corn, the seed ears may be stored in racks arranged in the hay mow or other place where they will keep dry, and be out of reach of mice and rats. There is no better way or defeating the attempts of these animals than by placing the ears in racks or on shelves where there is plenty of daylight between and around them. Rats and mice do not take kindly to such quarters.

It never is advisable to store seed ears with the husks on, as this is an unnecessary tax on space and prevents the grain from drying. Unhusked ears thrown into an ordinary crib and picked out for seed the following spring often prove satisfactory, but they oftener do not. Storing in barrels or boxes also is to be discouraged. Do not place the ears over a stable where moisture rising from stabled animals may collect upon the corn.

Seed corn is often stored in open sheds, the ears being tied up in bunches of two or three and hung to the rafters or elsewhere. Protection from rain or snow blown through cracks should be provided.

The prudent farmer will save about twice as much seed as he will likely need. This will fortify him against emergencies. The surplus seed usually can be sold at good prices to less enterprising neighbors.

FEEDING CORN.

Radical changes have occurred in recent years in the methods of feeding corn. It used to be fed extensively in the ear, the husks being previously removed. It also was often fed unhusked, as is still the custom in feeding certain kinds of stock. Feeders of beef cattle as a rule used to feed corn in the unhusked ear, but it is now more commonly fed shelled. It used to be the practice to break the unhusked ears into three or four pieces for feeding to cattle. This method of course precluded the possibility of using the cob to best advantage. The stover, usually much damaged by exposure to the weather, was fed on a sloping area in a pasture or in a lot where cattle, horses, sheep and hogs had access to it at the same time. Only a small percentage of its value as a roughage was realized when fed in this wasteful manner, as the stock after tramping over it and incorporating much of it in the muddy supply fed the previous day would eat only a few leaves or nubbins for which

they would diligently seek. It is obvious that in feeding corn the stockman of a decade ago lost most of its actual feeding value.

Present methods are on the whole less wasteful. Many farmers secure practically the maximum value of the entire plant. Machinery in great variety fortunately has come to their aid in this matter, the various grinders, shredding machines and silage cutters making it possible to work up the forage, ears, cobs and husks into feed relished by stock. Corn-and-cob meal, a valuable and extensively-used beef-making material made by grinding at one and the same operation the grain and cob, affords a good illustration of what machinery has done for the corn farmer. Coarse meal made of the grain and cob is economical and highly prized by feeders. Cobs are too valuable for feed to burn or allow to decompose.

Shredded fodder is another highly esteemed feed which is used quite extensively in some sections. This material is difficult to keep without molding unless put up in the proper stage of maturity. For this reason it has not grown fast in popularity. Machinery for shredding does its work admirably. There are several good types of shredders.

Corn fed as silage enables the feeder to secure the entire feeding value of the crop. Silage, therefore, is perhaps the most economical form in which to utilize the crop.

SILOING CORN.

A few other crops have been siloed successfully, but corn remains the peer of all silage crops. For this purpose a variety with abundant foliage and comparatively small stalks or stems is most desirable, though by planting thickly any variety will serve acceptably. Corn for silage should be planted thickly in hills or checks, or drilled in rows $3\frac{1}{2}$ feet apart as early as conditions warrant, and if given proper cultivation ought to yield from 12 to 18 tons of green fodder per acre. An early-maturing variety should be planted where frosts usually occur early in autumn.

It is the consensus of opinion among dairymen who have made the subject of silos and siloing a careful study, that the best time to cut corn for the silo is when the kernels begin to glaze and their indentations are well defined. It is better to cut the corn a little late than too early, as silage from very immature corn often sours and molds. Where the force of men is small and the amount of silage to be put up large it frequently happens that some of the corn will be cut too green and some too ripe. To guard against this contingency, a successful plan is to make three or four different plantings, say a week apart, for silage corn.

Not only does corn cut at the proper time keep better than green silage, but it also contains more dry matter or nutriment when al-

lowed practically to ripen before going into the silo. If corn is harvested for the silo after the kernels have begun to glaze, while the leaves are still green and before they show dryness, other conditions being favorable, it will meet every requirement for good silage.* Where any considerable acreage is to be cut the modern corn binder should be used. Otherwise the old-fashioned corn knife or some form of sled cutter may be employed. In no line of farm work is there better opportunity for coöperation than in the building and filling of silos. Several farmers can work together to great advantage in the purchase and use of silage machinery. In case two or more farmers are to use the same corn binder or other silage machines, their plantings of corn for silage ought of course to be made at different times, so that their respective crops may not reach the desirable stage for cutting at the same time.

To haul the fodder from the field to the cutter with the least amount of labor, a low wagon should be used, so that the bundles or loose fodder may be loaded and unloaded without having to be tossed several feet, as in the case of the ordinary farm wagon. Metal wheels of all practical heights and made to fit skeins of any size should be put on the wagon when silage is to be transported.

There are several brands of effective silage cutters. Most farmers prefer the corn cut into one-inch lengths. Care should be taken to fill the silo uniformly. As the silage comes from the blower or elevator it should be evenly scattered in the silo, and tramped down well, especially around the edges. In order to utilize the silo space to best advantage the silo should not be filled entirely on any one day. From 8 to 10 feet at a time is recommended. This gives the material time to settle, so that when finally filled, the silo will contain its maximum amount of silage. It is a waste to have only about 60 tons of silage in an 80-ton silo.

Difference of opinion exists as to the necessity of covering silage, likewise as to the kind of covering to use. Many experienced users of silage prefer a layer about 18 inches thick of good wheat straw over the silage and a roof over the silo. Oat straw is often used where wheat straw is not available.

Under ordinary conditions corn can be siloed at a cost of from 20 to 60 cents per ton. Considering the important advantages derivable from the use of this feed and the small cost of securing it, one who has fed it wonders why every farmer who raises sheep or dairy cattle and lives where corn is a successful crop does not put up a silo and feed silage. In recent years it has gained considerable added popularity as a feed for fattening steers, being fed successfully in conjunction with different concentrates and coarse dry fodders. It is especially valuable, however, for feeding dairy cows and

*W. H. Jordan: "The Feeding of Animals," p. 221.

working ewes, furnishing a succulent, appetizing provender that is fairly well-balanced and tends to keep the system in good order. The composition of dent and flint corn silage is thus stated by Voorhees:*

Pounds Per Hundred.	Water.	Crude fat.	Crude fiber.	Crude protein.	Crude ash.	Carbohydrates.
Flint corn silage,	79.0	0.7	4.3	2.0	1.1	12.1
Dent corn silage,	79.0	0.5	5.6	1.7	1.2	12.0

Silage is a first-rate substitute for green grass. It occupies small space, enables the farmer to save the stalks and leaves as well as the ears of his corn crop, can be put up at a time of year when farm work ordinarily is not pressing and can be fed very conveniently.

When sweet and well-made, silage is greatly relished by dairy cows, as well as by some other classes of stock, and they utilize it profitably. It is the dairyman's most reliable feed for use in combination with certain other kinds of provender, keeping cows in a healthy condition and up to their best performances at the pail. Prof. Henry regards it as pre-eminently a food for the cow.†

Silos can be built cheaper and better now than ever before, and a good one will last a lifetime. It seems a short-sighted policy to forego the use of silage merely because it is first necessary to erect a silo. The man who farms according to business principles cannot afford to waste about one-third the feeding value of his corn crop. He is the man who builds a silo and thus saves the entire corn plant.

THE SCORE CARD AND JUDGING.

Score cards in live stock and grain judging have come into general use in agricultural colleges during the past five or six years. As aids to systematic work in the critical examination of animals and grain, especially corn, they have proved conspicuously effective.

Although he has probably handled thousands of ears of corn, the average farmer who has not familiarized himself with the subject of corn judging through the use of a score card, could probably not correctly answer the question, What constitutes a good ear of corn?

If he does not know the points of corn, the farmer cannot be expected to be a successful breeder of this cereal. He must know the

*E. B. Voorhees: "First Principles of Agriculture," p. 202.
†W. A. Henry: "Feeds and Feeding," p. 256.

ideal type before he can produce it in the field. The score card or standard of perfection is designd to be of assistance in this direction. It is a guide to the methodical study of the external characteristics of corn. It directs attention to all the points which constitute a perfect ear of corn. It enables the student properly to estimate the economic value of the different points. It is a collection of important yet simple lessons put into pedagogic form.

Score cards for judging corn have been arranged by corn growers' associations in several states, Illinois being the first to formulate one. Indiana, Iowa, Nebraska, Missouri and Kansas soon followed in the order given. The several score cards are very similar in general, yet there is a difference as to the proportion of corn to cob, some of them giving 15 points and others 20 points. There are still other less important differences which have grown out of personal fancies in some instances, and, in others out of the individuality of the corns commonly grown in the different states. Changes have been made in the Illinois score card in recent years, and others are likely to be undergone as the work of corn improvement progresses. The general score card now in use in Illinois is as follows, the figure or figures following each item indicating the relative value of the different points when all points are scored as perfect:

THE ILLINOIS SCORE CARD.

1. Uniformity	a. Trueness of type,	5
	b. Uniformity of exhibit,	10
2. Shape of ear,		5
3. Color,		10
4. Market condition,		10
5. Tips,		5
6. Butts,		5
7. Kernel uniformity,		5
8. Kernel shape,		5
9. Length of ear,		10
10. Circumference,		5
11. Space	a. Between rows,	5
	b. Between kernels at cob,	5
12. Proportion of corn to cob,		15
Total,		100

Corn is judged by samples comprising 10 ears. This number gives a trustworthy idea of the leading characteristics of the variety, and facilitates the work of scoring.

The following explanatory notes on the different items in the

score card are given on the basis of 10 ears. The work of judging is also considered along with each point.

Uniformity.—Trueness to type and uniformity of exhibit are essential in a sample designed for display at a corn show. If for illustration the 10 ears are of the Leaming variety, they should be true to the accepted type of that corn; that is, the ears should have the proper length, circumference and the other less conspicuous characteristics which distinguish it from any other variety. If the type is unobjectionable a full score of 5 points is given. The ears should be of uniform size and general make-up. Where four or five of them are considerably shorter or smaller than the others the judge should make a cut of one point for each.

Shape of Ear.—Each recognized variety has a standard for the shape of the ear, but a cylindrical ear very slightly tapering toward the tip is sought in all general exhibits. If the shape of each ear in the sample conforms to the standard for the variety, a perfect marking of five points is given. Where the shape is partially at variance with the standard the rating given should be, say, 1.2 points. If five of the ears are objectionable from the standpoint of shape, the score might be 2.5. Those ears which shell the most corn as a rule carry their circumference well down to the tip and are harmoniously proportioned. If they are more than 10 inches long they should be more than seven inches in circumference. If an ear is shaped properly it usually scores high on other points.

Color.—Ten points are given for purity of color. Each ear in the sample should conform to the accepted color of the variety represented. Yellow corn should possess its typical yellow color and white corn its typical white color. At present a standard yellow ear with a white cob or a standard white ear with a red cob is barred from competition in a well-regulated corn show. The color of the cob is associated with purity of breeding. Therefore, a red cob in a white corn or a white cob in a yellow corn indicates impure "blood." Similarly a red or white kernel in a yellow ear or a yellow or red kernel in a white ear is proof of mixed breeding. Purity of color is of much importance as, for example, if an ear of a yellow corn with two or three white kernels be planted the resultant crop will show a considerable percentage of white kernels, possibly a number of ears entirely white, due to the pollen from the plants produced by the three off-colored kernels. It seems that a scrub or mixed-bred corn, like a scrub male in animal breeding, has greater fecundating power or else is more successful in using it than a pure-bred animal or seed. This may be due to the effort of nature to perpetuate those types or races which are bordering on extinction through man's attempt to eliminate them. In judging

corn, an ear with more than five mixed kernels is cut one point. Missing kernels are similarly scored. A very critical examination is necessary in order to detect all off-colored kernels. Those in the central portion of the ear are easily found, but those at the butt or tip are more difficult to discover. As a matter of fact, it is impossible to make a thorough examination without shelling the corn off the cob, as in many cases kernels are discolored below the caps or apexes, so that when on the cob their color defects are not visible. If he were growing seed for sale the writer would try to breed it true to color. If in this he succeeded only partially, as likely would be the case, he would then exercise great care in selecting seed ears, rejecting all having cobs of the wrong color and plucking out all the off-colored kernels. But for seed thus selected a high price would of necessity be charged.

Market Condition.—When judging a sample of corn to determine its soundness or market condition, each ear is taken in the hands and given a vigorous twist. If it does not yield to this test of its rigidity, thus giving proof of soundness and maturity, it may be approved as to market condition, provided there are no worm or mice-eaten kernels or injuries from disease or other cause. If the kernels are somewhat loose, and the cob is easily bent or twisted, the market condition of the ear is not good.

Corn prematurely harvested or that injured by frost usually shows those defects which count against market condition. An ear, to pass successfully the test for condition, should be perfectly rigid, the kernels close-set and firm on the cob, free from mutilation and fresh and bright in color. The farmer who, after feeling an ear and manipulating it in his unscientific way, says it is "solid and sound" has a good idea of what market condition means. Corn faultful from the standpoint of market condition invariably is objectionable as seed. It is always deficient in vitality. Hair-splitting work cannot be done in judging corn as to market condition, but an experienced judge will be able to score this point fairly. If half of the ears are light and chaffy or injured by disease or other cause a score of five points would be about right for the sample.

Tips.—More importance used to be attached to the matter of well-filled tips than at the present time, and 10 points instead of five were given for perfection in this characteristic, but experience has shown that from the economic point of view a perfect tip is not worth 10 points out of the 100. Ears may be perfectly tipped and yet be smaller yielders than those with bare tips. A well-filled tip is desirable, however, on an ear that is otherwise a good type. It stands to reason that naked cob surface means a reduced percentage of grain.

Several enthusiastic plant breeders argue that by constant selection of ears having filled tips a variety can be so improved in this regard that ultimately the characteristic will be firmly established. In the light of present information other more conservative corn specialists decline to subscribe to this doctrine. Well-filled tips they seem at present to regard as a point entirely outside the realm of heredity. The extent to which tips are filled is governed largely by fertilization and the food and water supply of the plants. If all silks, each of which represents a kernel, are pollinated successfully the cob will contain in a favorable season as many kernels as can develop properly in the space available. Perfect pollination, therefore, means, in a propitious season, perfectly-filled tips and butts, provided of course that the corn enjoys freedom from insect pests and fungous diseases. Esthetically, the ear with kernels completely covering the tip, as shown in Fig. 16 is satisfying; theoretically it is alluring to the new corn breeder; practically, commercially, it is of value only in so far as it may insure more corn per acre. This a few men hold it fails to do in future crops. An ear with a perfect tip may outyield one with an inch of naked cob at the tip but there is no proof, it is asserted, that when planted it will produce more well-filled tips, the conditions being as nearly alike as possible, than the bare-tipped ear. Corn for exhibition, however, to be judged by the common standards of perfection, must be properly filled out at the tip ends of the ears. In scoring, naked tips are cut rather heroically, especially by judges with exuberantly artistic temperaments. Preference also is shown for ears with straight rows of kernels extending in unbroken line to the cap kernel, the theory being that where the rows are irregular or undefined at or near the tip a smaller number of kernels will occupy the space than were they in regular rows. Straight-rowed ears breed straight rows, and for exhibition they are much more desirable. They also as a rule outyield ears having crooked rows and consequently considerable space between the kernels or rows of kernels. Crooked rows of large, round flint kernels are sure to cause loss of space.

In selecting seed, it is advisable to discriminate against crooked-rowed ears, not only because they may transmit this character, but because of the lack of uniformity in size of the kernels. Where the kernels grow out of line like crowded teeth that have been neglected, they are of many shapes and sizes, these peculiarities being induced by the efforts of the developing kernels to adapt themselves to the limited space at their disposal. For planting, these kernels are of course objectionable; they cannot be distributed mechanically in uniform numbers. But there is no reason to believe that they would produce ill-shaped kernels, assuming that the ear is the unit.

Tip kernels never average as large or deep as those at or near the center of the ear for the reason that as they develop last they obtain only a small amount relatively of the food acquired by the plant from the soil and air, most of it going into the kernels which are first to be fertilized. No matter how favorable the season or rich the soil, no variety of corn will develop tip kernels as large as the central kernels. Butt kernels are often smaller than those below them because of the pressure of the husks around the butt of the ear.

Butts.—To conform to the score card, the butt of an ear must be well-filled, the rows of kernels reaching the shank in regular order, giving the butt a neat, clean-cut appearance and rounding out the physical beauty and symmetry of the ear. Fig. 12 (page 57), shows a perfect butt. Where the shank is removed, an even depression or

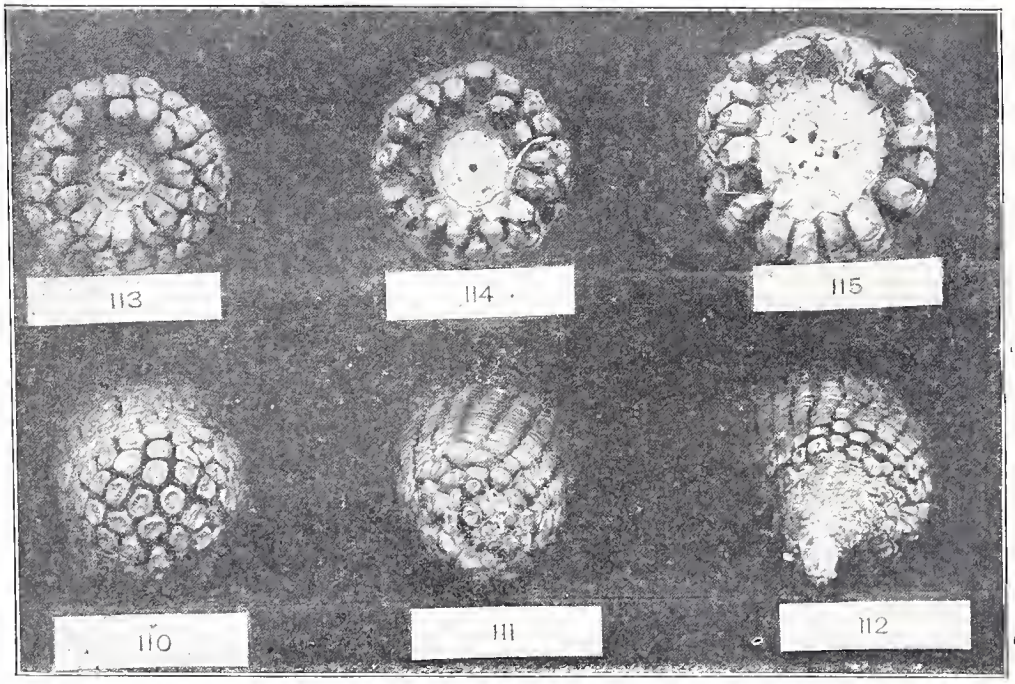

Fig. 13. Butts and tips, showing the good, bad and worse kind.

naked space about half an inch in diameter or larger, depending upon the variety and the size of the ear, should be visible. A large, open butt, such as that illustrated in Fig. 13 (No. 115), means a deficiency of butt kernels compared with a small round butt and is almost always associated with shallow kernels all over the cob. Ears with large shanks are, moreover, more difficult to snap or husk than those with smaller shanks, and are likely to hold the ears with the tips pointing upward, thus exposing the partially open ends to the rain. Long, coarse shanks, therefore, are objectionable from the several points of view. It is contended that the shank can be re-

duced in size by selecting annually for seed ears with small shanks. Reid's Yellow Dent is commonly mentioned as an illustration of this point. This variety has such a small shank that when fully matured and dry many of the ears will break off during hard winds. Ears of corn exhibited for prizes and judged according to score card rules cannot be too nicely filled out and rounded at the butts. If the butts are open and ragged and the point of shank attachment is as large as the cob itself a cut of one-half point is made for each ear, smaller deductions being made in the case of butts better filled. Fig. 13 (No. 115) shows a butt that scarcely could be worse. Grooming is often practiced by professional exhibitors of corn. It consists in tooling out the butts, removing the bit of projecting shank and forming a smooth-surfaced, globe-shaped depression in the end of the ear. It also includes the removal of all silks. The writer has judged corn which the exhibitors had tooled very artistically.

Kernel Uniformity.—By uniformity of kernel is meant size, shape and color. A white corn should have white kernels; yellow varieties

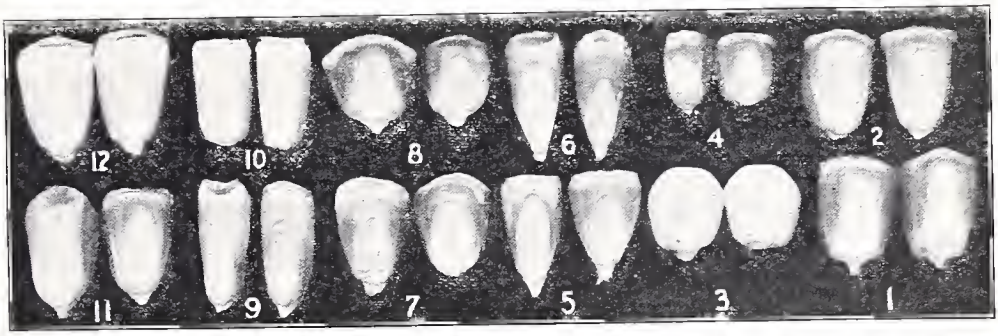

Fig. 14. Types of kernels, 1, 2, 11 and 12 being the most desirable in the order given.

yellow kernels. Each standard variety has a distinct type of kernel, though the difference is often slight between kernels of two or more corns of the same race. Dent corn and flint kernels are of course wholly dissimilar. To judge of their uniformity two kernels are removed from the central part of each ear and the ten sets placed in such position to each other as will best serve the purposes of comparison. The kernels may be easily removed with a pocket knife. The kernels should be of approximately the same length, breadth and thickness. The different pairs should not be mixed, as in that case the judge could not tell to what ears they respectively belonged. If, for illustration, five sets of kernels are of varying types, a cut of 2.5 points should be made. Tenths may be and usually are employed in scoring corn, as they expedite additions and simplify the work.

Kernel Shape.—The shape of the kernel will depend in large measure upon the variety, but all breeders of dent corns are seeking to perfect what is aptly called the wedge-shaped kernel. It is

a simple matter of physics that kernels of this shape can grow in larger numbers and to greater size than kernels of any other shape. The contour of the cob requires wedge-shaped grains to enclose it snugly and compactly. Several different types of kernels are shown in Fig. 14. Of these No. 1 is the best. This is the type which should be selected for planting; it goes with the ideal ear. It is the type which insures the largest yield of the best quality. Instead of breeding for a very long kernel it is better to develop length in harmonious proportion to its thickness and width. Long, narrow kernels have too much hull. A dent kernel of good type consists of about 7 per cent. hull.* In judging, the markings should be based on the number of kernels conforming to the standard. The kernels are examined in the same manner as when scoring them for uniformity.

Length and Circumference of Ear.—In length, the ears of standard varieties vary several inches. Long, slim ears with only 12 to 14 rows of kernels and big cobs are to be avoided. In selecting for exhibition purposes, the length of the ears should be in accordance with the variety standard. The tendency among progressive corn breeders is toward longer ears, but they are striving also to increase the circumference, thus preserving the proper proportions. Generally speaking, an ear should be from 10 to 11 inches, and if a little longer and of the right circumference, many growers would not object. It is argued that big ears are not borne in as great numbers as smaller ones and that, therefore, varieties with small ears will outyield these producing relatively large ears. The writer has not seen adequate proof of this contention.

In Illinois, the length and circumference of ears vary according to the section of the state in which the corn is grown. In Northern Illinois the standard for length is 9½ to 10½ inches and 7 to 7½ inches in circumference; in Central Illinois, where most of the State's corn is grown, the standard is 10 to 11 inches in length and 7½ to 8 inches in circumference, which also applies to Southern Illinois. The table below gives the names and the length and circumference of the seven standard varieties which are commonly grown in Illinois:

Name of Variety.	Length in inches.	Circumference in inches.
Riley's Favorite,	9 to 10	7
Golden Eagle,	9 to 10	7½
Silvermine,	9½ to 10½	7½
Leaming,	10 to 11	7½
Boone County White,	10½ to 11½	8
White Superior,	10 to 11	7½
Reid's Yellow Dent,	10 to 11	7½

*Bull. No. 87, Ill. Expt. Station.

The length is easily ascertained with a rule; for every inch in excess of or less than the standard for the variety a cut of one point is made. The excess or deficiency is easily kept in mind and aggregated as the measurements are made.

In determining the circumference, a piece of tape-line about 18 inches long is used, the measurement being taken at about one-third the distance from the butt to the tip.* For every two inches in excess or less than the standard calls for a cut of one point is made.

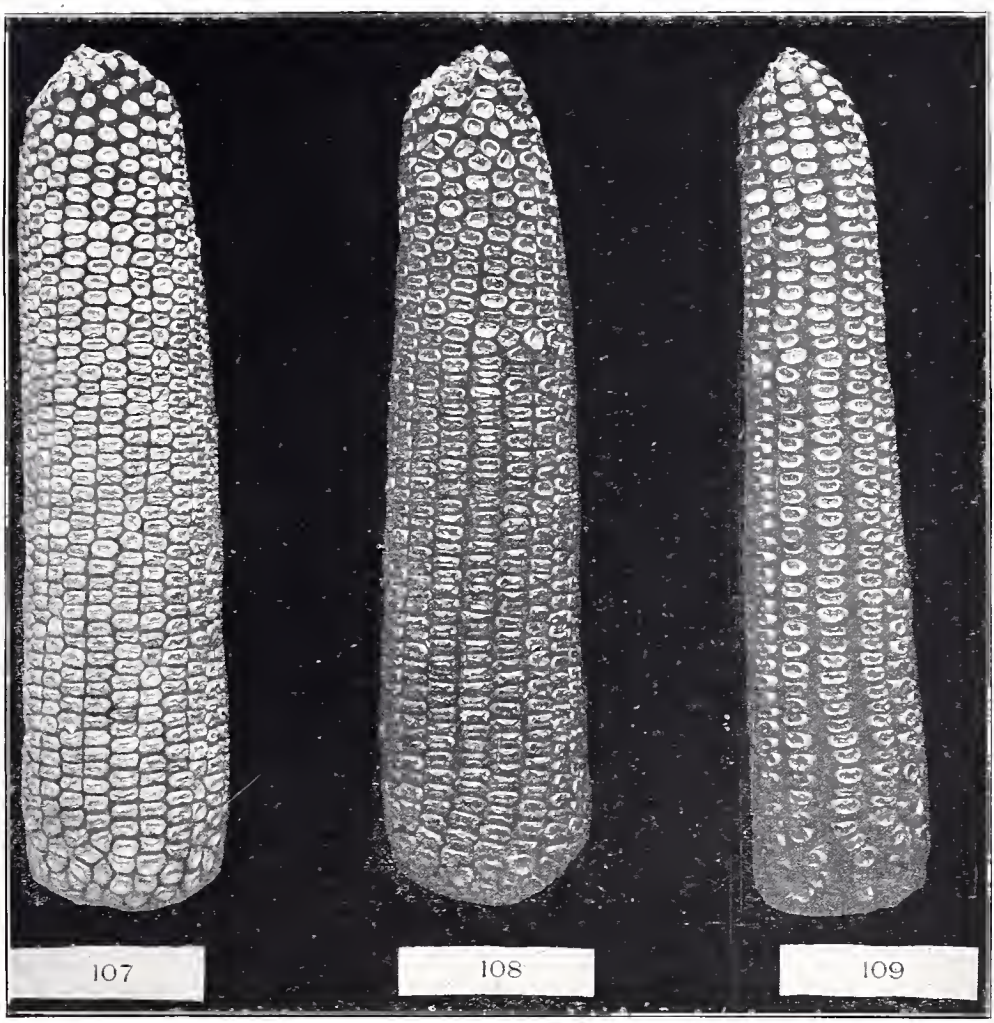

Fig. 15. Ears showing close-set, medium and wide-spaced rows.

FEEDING CORN.

Space.—It is desirable that kernels should set close together on the cob. Space lost between the rows, an excellent illustration of which is given in Fig. 15, means a smaller amount of grain compared with ears having close-set rows, such as Fig. 15 (No. 107) illustrates. Kernels of the proper shape and size on cobs of medium to small in size are as close together as they can grow. Shallow kernels, representing the type shown in Fig. 14 (Nos. 3, 8 and 4), al-

*A. D. Shamel: "A Manuel of Corn Judging," p. 64.

ways are placed further apart on the cob than those of the wedge-shape. The fewer the rows of kernels the greater the loss of space on the cob. Eight-rowed corns, which are commonly grown in some parts of the country, are the best illustrations of lost space. Improved dent corns, especially those with kernels of the rough projection dented type, are not as a rule open to objection on this score. It has always seemed to the writer that if we get a few fundamental points right in corn all the rest must of necessity be present. The shape or type of kernels determines their closeness

Fig. 16. Partially shelled ears, showing a large cob, a medium-sized cob and a small cob. The middle ear is the best type, having a deeper kernel than either of the other ears.

together on the cob. This being true the matter of space really is settled before it is reached in judging a sample by the score card. Space between rows cannot be determined to a mathematical nicety, although some judges attempt to measure the width of the space, reducing the perfect score of five points one-half point where the space is between 1-32d and 1-16th of an inch. It is in fact a question of mental scoring; a study of the ear will suggest the proper rating

to give it on this point. An ear like that in Fig. 15 (No. 109) the writer would cut one point on space; one like that in Fig. 15 (No. 107) he would not fault at all in this respect.

Proportion of Corn to Cob.—As the percentage of grain to cob is determined by the scales, maturity and dryness of the corn are essential. Ears for exhibition should be thoroughly dry. To ascertain the proportion of corn to cob, according to the arbitrary scheme which the Illinois Corn Growers' Association has evolved, weigh five representative, typical ears of the 10 in the sample, shell them, weigh the five cobs, deduct the weight of the cobs from that of the ears; the result will be the weight of grain, which divide by the total weight of the five ears. This will give the per cent. of corn to cob. The process may be illustrated thus: Suppose the five ears weigh five pounds or 80 ounces, and the cobs 10 ounces; the difference be-

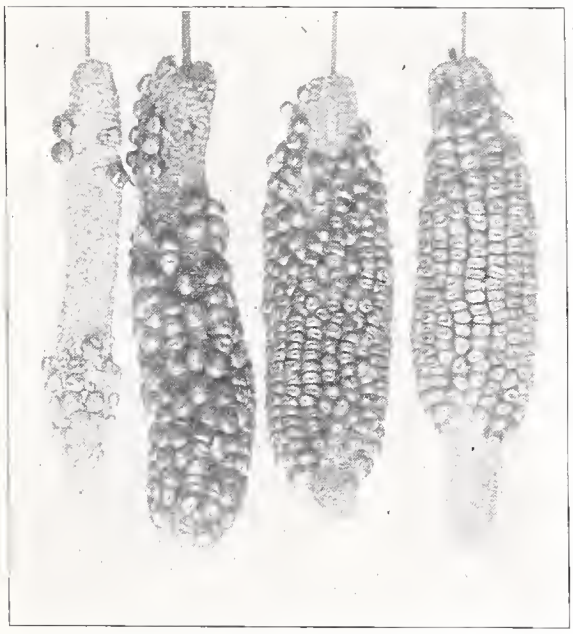

Fig. 17.

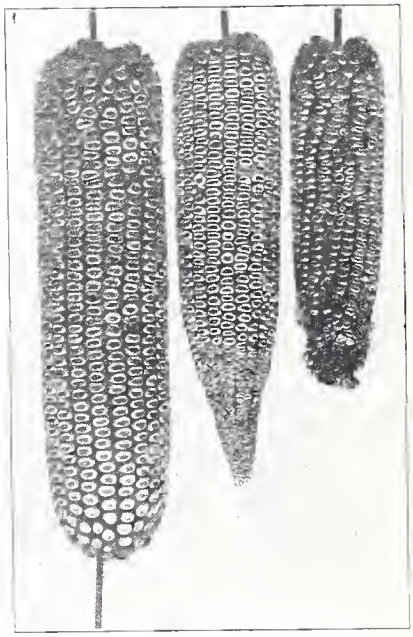

Fig. 18.

Fig. 17. Samples of corn which is too common. These nubbins are largely the result of poor seed, and show the necessity of corn-improvement.

Fig. 18. A case of evolution.

tween 80 ounces and 10 ounces is 70 ounces or the weight of the grain; 70 ounces divided by 80 gives 87.5, the percentage of corn to cob. Dent corns vary from 86 to 90 per cent. in proportion of corn to cob. In judging, a cut of .5 of a point is made for each per cent. short of the standard.

Corn judging, like stock judging, cannot and should not be a mathematical process. It involves an intelligent balancing of merits and defects, and their equitable and just valuation. Once a man learns what constitutes the best type of ear, he has no further use for the score card except in demonstration or instructional work.

Points of greatest commercial value should be given first consideration. Present score cards are unnecessarily complicated; there is too much to them; some of the points could be merged or dropped altogether to advantage.

LOCAL CORN SHOWS.

To the influence exerted by local corn exhibitions may be attributed a great deal of the interest manifested generally in improved corn. For this reason whenever farmers begin improving corn they will find it profitable to themselves and helpful to others in their vicinity to make public displays of their corn, showing well selected, improved ears in comparison with ordinary corn. Such an object lesson would impress thoughtful men, and stimulate interest in better seed.

Corn exhibits may be held in connection with farmers' institutes, at county fairs or other farmers' gatherings. Ten ears make a convenient sample for judging. This is the number used at the corn shows in Illinois, Iowa, Indiana and Missouri. Intending exhibitors should if possible select their corn in the field, using the score card as a guide. Ears for showing should be thoroughly dried, and if they are to be shipped any considerable distance each should be wrapped in a piece of paper, and the ten specimens placed in a box that will contain them snugly. Do not tie up samples with wire or twine; this will mutilate the ears and make against success. A competent judge should be secured to judge the corn and give reasons for his decisions. Type is the essential point to emphasize. The judge should point out why one ear shells more corn to the cob than some other ear, discuss all the characteristics and show the "why" in every case.

Displays at institutes will generate interest. Cash prizes should be offered for white and yellow corns. The first prize might be $1.50, the second $1 and the third 50 or 75 cents. Local merchants usually can be induced to offer merchandise. The writer once judged corn at an Illinois farmers' institute where $500 worth of dry goods, shoes and groceries were listed as prizes. Competition was keen and the entries represented every township in the county.

The local corn show helps materially to arouse interest in improved seed, and thus is an important part of the educational campaign.

SUMMARY.

1. Pennsylvania's average yield per acre of corn is about 32 bushels. The yield can be increased by growing more corn per acre or by planting more acres.

2. Southern Mexico is the native home of corn. It is a crop of remote antiquity.

3. The corn plant has male (tassel) and female (silks) parts, and belongs to the grass family. Its botanical name is Zea Mays.

4. By corn-belt, is usually meant the states of Illinois, Iowa, Missouri, Kansas, Nebraska, Indiana, Ohio and Wisconsin. The corn-belt is expanding, owing to the evolution of early-maturing varieties of corn and the improvement in farm practices.

5. Corn is the most important crop in America. About 2,500,000,000 bushels are produced annually in the United States. It is the peer of all meat-making foods.

6. The uses to which corn is now put are numerous, and increasing. Most of it is used in feeding live stock. Many articles of commerce are manufactured from it. The days of 25-cent corn are past.

7. Corn breeding was not begun in a definite way until about ten years since, when Dr. Hopkins started it in Illinois. Results show that corn can be greatly improved chemically and physically. The work is still in its infancy. Its possibilities are of large commercial significance.

8. The oil content of corn has been increased and decreased by breeding, making it more valuable for glucose in the one case and for feeding in the other. Protein also has been increased in several varieties of corn, enhancing its value as feed for animals.

9. There are hundreds of so-called varieties of corn. Only seven are recognized by the Illinois Corn Growers' Association. A system of nomenclature is needed to protect farmers against deception by dishonest dealers who use new names.

10. There are six distinct races of corn: Dent, Flint, Pop, Sweet, Soft and Pod. Dent corns are the most important commercially. Flints are grown chiefly in New England and in northerly latitudes.

11. Leaming (yellow) and Silvermine (white) are believed to be dependable varieties for Pennsylvania.

12. At present there is, strictly speaking, no such thing as "pure-bred" corn. It will require years of careful breeding to establish absolute purity in any variety. The word "pure-bred" is a misnomer. Seedsmen use it as a bait-catcher. There are improved varieties of corn, which are superior to nondescript corns for seed, but as yet no pure-bred corn has been grown.

13. In buying seed insist upon getting it in the ear. This is the only way to judge of its merits. The ear is the unit, and consequently the basis of improvement. If the ear is not right the crop cannot be expected to be right.

14. Test seed for vitality. It should test 97 per cent. in order to insure a good stand in the field. Testing is easily done. Much corn of weak germinating power is planted, resulting in ragged stands. A good stand is half the battle.

15. Corn thrives in a large variety of soils, but a deep, black, well-drained soil is best adapted to it.

16. In hilly regions, land is made poor by soil erosion or washing. This can be prevented by a system of cropping, and thin, barren soils made profitably productive.

17. Corn plants require food—they eat and drink. Nitrogen, potassium and phosphorus are the principal elements of plant food. All must be available in proper amounts to insure good crops of corn.

18. Nitrogen costs commercially about 15 cents per pound; it can be secured from the air through leguminous crops for less than a cent a pound. No farmer, therefore, should purchase it commercially. It is needed on many types of soil for best results in corn growing.

19. Soils which produce practically no corn can be made to grow maximum crops of it. This has been often demonstrated. Soil improvement is practical, and it pays.

20. Peaty or swamp soils can be made remunerative as corn land by the application of potassium.

21. Thorough preparation of the seed-bed for corn is essential. The field should be worked until in fine condition.

22. Planting should begin when soil and climatic conditions warrant. Seed should be graded and the planter tested and regulated to drop a uniform number of kernels. Seed should be planted from two to three inches deep.

23. A careful operator can make rows straight both ways with a two-horse planter if proper precautions are taken. Straight rows facilitate cultivation. Hand planters are extensively used in some sections.

24. Cultivation should begin before the seed germinates, a harrow being used. Until the plants are in an advanced stage of growth, a weeder is the most effective cultural implement. The field should be worked as soon after rains as possible to prevent the formation of a surface crust.

25. Shallow or surface cultivation gives better results than deep plowing of corn. Deep culture injures the roots.

26. Corn plants require a large amount of water. Keep the surface fine and loose by frequent cultivation and thus conserve the soil moisture.

27. In "laying by" corn do not throw dirt up against the rows and thus form ridges in the field. Finish cultivation with an implement which leaves the surface smooth.

28. Replanting when necessary may be done with hand planters. Replant-corn, if late, seldom yields more than a few nubbins.

29. Detasseling can be done with advantage in breeding plots where the aim is to prevent inbreeding. Intelligently done it will increase the yield.

30. Barren stalks in breeding plots should be removed before their pollen matures, as barrenness is believed to be transmissible.

31. Many species of insects prey upon corn or its plants. Only a few are seriously injurious. Crop rotation is the most satisfactory method of combating most of them. Of the fungus diseases affecting corn, smut is the most important. It is difficult to eradicate.

32. Harvesting from standing stalks is the common practice. Afterward stock is turned into the fields. More feeding value is realized from the crop where it is cut and shocked.

33. Seed corn should be selected in the field at time of harvesting the crop. It should be stored where it will keep perfectly dry. In this condition it will not suffer injury from cold.

34. Methods of feeding corn have changed. It is now fed largely in ground form, in many cases with the cob, also ground.

35. Siloing saves the entire plant, and gives the farmer its full feeding value. Silage is a highly-esteemed food for dairy cows. It also is used successfully in steer feeding. Corn for silage should be cut when well dented. It costs from 20 to 60 cents per ton to silo corn.

36. Score cards for judging corn are used at many of the agricultural colleges. They teach the points of corn. Corn judging is not a mathematical process. It is important for the farmer to know what constitutes a score card ear of corn if he intends to breed corn.

37. Seed ears should be from 10 to 11 inches in length, 7 to 8 inches in circumference, cylindrical in shape, with deep wedge-shaped kernels set tightly and closely together on a medium-sized cob.

38. Local corn shows arouse interest in good corn and better seed. Farmers who grow good corn for seed should get up corn exhibits.

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